

Treatment effects on cluster development in the speech of 4-year-old children with speech disorder

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The material presented in this thesis is the original work of the candidate, except as acknowledged in the text, and has not been previously submitted, either in part or in whole, for a degree at this or any other university.

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Abstract

Purpose: This study examined the effectiveness of two differing interventions to improve the consonant cluster production in six children aged 4-5 years with concomitant speech sound disorder and expressive language difficulty.

Method: Participants were selected for the study based on a high incidence of consonant clusters errors in their speech production. All participants had at least 75% of their cluster production attempts in error in their initial speech sample. The participants were randomly assigned to receive 24 hours of either a phonological awareness intervention with integrated speech targets (Gillon & Moriarty, 2005), or a morphosyntax intervention which alternated therapy sessions for language and speech targets (Haskill, Tyler, & Tolbert, 2001) Each intervention was administered in two blocks of 6 weeks separated by a 6-week therapy break. Hour-long small group intervention sessions were attended twice weekly by all participants.

Consonant cluster productions were assessed using speech probes and standardised speech assessments. These were administered pre-intervention, post-intervention, and at follow-up 3 months post-intervention. These measures were compared to identify any improvement in (a) word-initial cluster accuracy as a result of /s/ clusters being targeted in the phonological awareness intervention;(b) word-final cluster accuracy as a result of word-final morphemes being targeted in the morphosyntax intervention; and (c) cluster element accuracy as a result of improved production of the phonemes as singletons.

Results: The data supported the hypotheses that targeting word-initial clusters in the phonological awareness intervention would lead to improvements in accuracy for target /s/ clusters, non-target /s/ clusters and singleton fricatives. Improvements in production of /s/ clusters, singleton fricatives, and untreated consonant + liquid

clusters were significant for all participants in this intervention type. The improvement for word initial /s/ clusters was greater than for the treatment group who received morphosyntax intervention.

The data was less convincing for the hypothesis that word-final cluster production would improve following intervention for word-final morphemes in the morphosyntax intervention. Although there was improvement in word-final production for two of the participants in this group, there were similar or greater improvements seen for the children who received phonological awareness intervention in which word-final clusters were not targeted.

The data supported the final hypothesis that improved production of singletons following speech intervention for these phonemes would result in improved accuracy for the phonemes when attempted in the context of clusters. All participants had improved accuracy of cluster elements that had been singleton targets during intervention.

Conclusion: The data showed that the Phonological Awareness intervention led to significant improvement in production of the target /s/ clusters, and generalised to increased accuracy for production of singleton fricatives, non-target /s/ clusters, and untreated consonant + liquid clusters. The Morphosyntax intervention resulted in less consistent improvement in production for target word-final clusters. In this programme, word-final clusters were implicitly treated through language intervention for word-final morphemes. The data indicates that improvement in consonant cluster production is facilitated when using explicit teaching methods to introduce and practice consonant clusters during intervention with children with speech sound disorder.

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Chapter 1

Literature Review

1.1 Introduction

Children with speech sound disorder with unknown cause are estimated to represent between 3 - 7% of the population of children aged 5-7 years (Beitchman, Nair, Clegg, & Patel, 1986; Broomfield & Dodd, 2004; Gillon & Schwarz, 1999; Shriberg, Tomblin, & McSweeny, 1999). These children are at significant risk of presenting with concomitant difficulties with language and/or phonological awareness development (Crosbie, Holm, & Dodd, 2005; Larrivee & Catts, 1999; Rvachew & Grawburg, 2006; Stackhouse, Wells, Pascoe, & Rees, 2002). Researchers have correlated poor phonological awareness with difficulty acquiring reading and spelling skills in early school years (Gillon, 2005; Hogan, Catts, & Little, 2005; Larrivee & Catts, 1999; Rvachew & Grawburg, 2006). Intervention that targets phonological awareness skills at preschool level has been shown to improve reading outcomes in the early school years (Gillon, 2005).

This research identifying links between speech sound disorder, phonological awareness, and early literacy difficulties has come at a time when health and educational services are seeking evidence that the services provided through government or insurance funding are both evidence-based and effective. The speech-language therapy profession is striving to demonstrate that the intervention provided to our clients is both effective and efficient. Because of this, attention has increasingly focused on treatment efficacy through comparison of the pre- and post-intervention performance of children with speech and/or language disorders.

To date, the majority of speech intervention efficacy studies have focussed on the effect of intervention on the speech system as a whole following intervention,

rather than examining - specific speech sounds or structures within that system (Gierut, 1998b; Gillon, 2005; Tyler, Lewis, Haskill, & Tolbert, 2002).

The current study examines the impact of intervention on a specific area of the participants' speech development, namely the development of consonant clusters. Previous research on consonant cluster development has frequently focussed on defining the order of acquisition (Kirk & Demuth, 2005; McLeod, van Doorn, & Reed, 1997; Smit, 1993), and the likely patterns for incorrect productions for young children with typical development (Greenlee, 1974; Smit, 1993) and children with speech sound disorder (Chin & Dinnsen, 1992; McLeod et al., 1997). There has been little research to date focussing on changes in consonant cluster production as a result of intervention. This is somewhat surprising as cluster reduction is one of the most common and longest lasting phonological processes for young children with speech sound disorder (Chin & Dinnsen, 1992; Hodson, 2007; McLeod et al., 1997; Stoel-Gammon, 1987; Wyllie-Smith, McLeod, & Ball, 2006).

Researchers have suggested that consonant clusters should be considered as speech targets in intervention because of their high frequency in English and the impact of cluster reduction on intelligibility (Hodson, 2007; Smit, 1993).

Furthermore, developing an understanding of the impact of intervention on cluster representations is significant, as several researchers have suggested that targeting clusters can lead to greater system wide change in children's phonologies than targeting singletons (Gierut & Champion, 2001; Gierut & O'Connor, 2002; Hodson, 2007).

In the current study, two differing approaches to intervention for children with both speech and expressive language disorder are compared. These are a phonological awareness intervention with integrated speech targets (Gillon & Moriarty, 2005), and

a morphosyntax intervention which alternates therapy sessions for language and speech targets (Haskill et al., 2001). The impact that these differing intervention approaches have on the production of consonant clusters by six 4-year-old children with speech sound disorder is examined.

1.1.1 Speech Sound Disorder

In the early years of life, children primarily use spoken language and gesture to communicate. Many young children with communication difficulty present with speech that is difficult to understand. This can be due to motor difficulties (i.e., an inability to physically articulate sounds) or to cognitive difficulties (i.e., poor underlying phonological representation of sounds).

1.1.2 Definitions

A variety of terms are used in the literature to describe the speech of children who have unintelligible speech with no known cause. For these children, speech difficulty is not a result of hearing impairment, cleft palate, cognitive or physical impairment, neurological injury, or syndromes (e.g., Down syndrome). These terms include: functional articulation disorder, expressive phonological disorder, speech impairment, speech sound production disorder, developmental phonological disorder, speech delay, intelligibility impairment, and speech sound disorder (Bernthal & Bankson, 2004; Bleile, 1995; Crosbie et al., 2005; Gillon, 2005; Grunwell, 1982; Hodson, 2007; Shriberg et al., 1999).

Dodd (2005) has suggested that the difficulty in selecting one definition may be due to the fact that children who present with speech sound disorder are a very heterogeneous group. They present with different:

1. severity of disorder

2. type/s of speech errors
3. type/s and severity of concomitant language difficulties (if any)
4. responses to intervention
5. knowledge of, and responses to, their speech difficulties

All of these possible variations result in a group of children identified as having speech difficulties but potentially very different presentations.

As well as these variations in presentation, researchers have defined speech difficulties based on different theoretical foundations. Since the 1980s, authors have tried to describe the speech sound errors of highly unintelligible children by grouping their errors together. Groups of sound errors resulting from changes in manner or place of production are described by phonological patterns (e.g., velar fronting, final consonant deletion, deaffrication). Grunwell (1982) suggested that children with “phonological disability” may present with different types of speech sound error patterns depending on the types of sounds attempted. That is, different manner or place of production may result in different types of phonological processes being used. They suggested that children with “phonological disability” will present with one or more of the following difficulties:

1. Continued use of normal phonological processes (beyond the usual age for suppression of these processes);
2. Chronological mismatch in production of sounds (i.e. early simplifying processes being used at the same time as later developing sounds);
3. Variable use of processes which can result in unpredictable productions or unusual processes used (e.g., deletion of initial consonants).

Shriberg et al. (1997) used a broad definition where children aged 3;0 to 8;11 years old with no clear organic cause for their speech difficulties but with speech

sound errors that effect intelligibility are categorised as having “speech delay”. This definition is used in the Speech Disorders Classification System (SDCS). Children with distorted productions for target sounds are excluded from this group, but those with substitution errors and omissions are included.

Dodd (2005) split children with “speech disorders” with unknown cause into four subgroups. These were:

1. Articulation disorder – where a child mispronounces a few specific phonemes (often /s/, /θ/, or /r/) in the same way, in all contexts.
2. Phonological delay – where error patterns that are typical for younger children are used beyond the age we would expect them to be suppressed.
3. Consistent phonological disorder – where a child consistently uses non-developmental error patterns. The child may present with age-appropriate or delayed use of developmental error patterns as well as the non-developmental error patterns.
4. Inconsistent phonological disorder – where a child presents with 40% or more variability in their use of phonological error patterns.

Hodson (2007) used the term “expressive phonological disorder” to describe any children with highly unintelligible speech, who have deviations in their understanding and use of the sound systems of a language.

As can be seen from this brief overview there are a wide range of terms that could have been adopted to describe the speech of children with communication problems secondary to speech difficulties without known cause (i.e., not due to sensory, cognitive or physical difficulties). For the current study the term ‘speech sound disorder’ has been used.

1.1.3 Prevalence

Children with speech sound disorder with unknown cause make up a large proportion of caseloads for many paediatric speech-language therapists. Prevalence studies which estimate the proportion of a given population that present with speech sound disorder at a given time, have been conducted in the USA, Canada, the United Kingdom, and New Zealand (Beitchman et al., 1986; Broomfield & Dodd, 2004; Schwarz & Gillon, 1998; Shriberg et al., 1999). These prevalence studies have estimated that between 3% and 7% of junior primary school children have speech sound disorder with unknown cause.

A screening study conducted in New Zealand assessed the speech and language abilities of 972 six-year-old children (Schwartz & Gillon, 1998). In this study, 4.5% of the children screened presented with speech sound disorder. Gillon and Moriarty (2006) extrapolated from previously reported prevalence studies to provide an incidence estimate for New Zealand children aged 5-8 years. Based on Ministry of Education statistics for school enrolment numbers in July 2004, they estimated that up to 8,581 (5%) of 5 to 8-year-old children would have speech sound disorder.

Similar results were found in a study conducted by Shriberg et al (1999) in USA. Their results were extrapolated to give a prevalence estimate of 3.8% for speech delay in 6-year-old children (Shriberg et al., 1997). Studies conducted by Beitchman et al. (1986) in Canada and by Broomfield and Dodd (2004) in the United Kingdom both reported higher prevalence estimates of 6.4% of children with speech sound disorder for the age groups assessed.

The purpose of these studies was to identify the prevalence of speech sound disorder, rather than to describe the specific difficulties of the children presenting with speech sound disorder. Research has also been undertaken that provides more in-

depth description of specific aspects of the speech systems of children with speech sound disorder. The development of consonant clusters is an area that has been investigated to further describe children's development of speech.

1.1.4 Consonant clusters

A consonant cluster is described as being two or more adjacent consonants in the same syllable (e.g., /br/ in *brush*, /skw/ in *square*, and /nt/ in *paint*). The consonants that constitute a cluster are referred to as cluster elements in this paper. Consonant clusters are very commonly used in English words. McLeod et al. (2001b) reported that one third of single syllables in English start with word-initial clusters. Many English words end in consonant clusters due to word-final grammatical morphological structures which can, but do not always, create word-final clusters. For example, the phonemes /s, z, t, d/ are added in word final position for the possessive form of pronouns (e.g., *it's*, *mum's*), plural nouns (e.g., *dogs*, *lips*), past tense verbs (e.g., *walked*, *climbed*), and third person participle verbs (e.g., *likes*, *loves*). Even with these morphological structures excluded, it has been reported that 18% of single syllables in English end with word-final clusters (McLeod et al., 2001b).

Words with consonant clusters have been reported in the vocabularies of children from the earliest stages of language development. Crystal (1986) reported the results of a study by Stoel-Gammon and Cooper which provided the first 50 words in the vocabularies of three children. Between 12% and 14% of the first 50 words used by each child had consonant clusters. Word-initial clusters (e.g., *block* and *frog*) occurred more often than word-final clusters (e.g., *orange*) in these vocabulary lists.

Studies describing vocabulary used by older preschool children have found similar proportions of words containing consonant clusters to those reported by Crystal (Beukelman, Jones, & Rowan, 1989; Fried-Oken & More, 1992). For

example, Beukelman (1989) reported on the vocabulary used by six children with typical development aged between 3;8 and 4;9 years. Of the 250 most commonly used words in the speech samples, 16% (40/250) had consonant clusters in word-initial and/or word-final position. In this study word-final clusters were more common than word-initial clusters (24/250).

As consonant clusters have been shown to be not only common in the English language, but also specifically in the vocabulary of young children, it is important to know how these clusters are produced during the early stages of speech development in both children with typical development and those with speech sound disorder.

1.1.5 Typical cluster development

Studies investigating the order of acquisition of consonant-clusters have primarily focussed on clusters in word-initial position (Grunwell, 1982; Smit, 1993; Stoel-Gammon, 1987). The order that young children acquire consonant clusters has been described from the analysis of normative study data. Grunwell (1982) reported that most typically developing children develop consonant + /l, r, w/ clusters first, followed by /s/ + consonant clusters (e.g., /st/ and /sp/).

Smit (1993) provided more specific data for order of acquisition, reporting that stop + /w/ clusters (e.g., *twin*, *queen*) were the earliest group of word-initial clusters to develop in the typically developing population in the Iowa-Nebraska Norms Project. These clusters were correctly produced by 55% of 2 to 3-year-olds and 75% of 4-year-old participants. Based on the data from this study, Smit (1993) suggested the following order of acquisition of word-initial clusters for English speaking children with typical development:

1. stop + /w/ clusters
2. /l/ clusters (except /sl/)

3. /r/ clusters (except /θr/
4. /s/ clusters (including /sw/)
5. /sl/ and /θr/
6. the three-consonant cluster /skw/
7. other three-consonant clusters

The definition for ‘age of mastery’ for this study was when 75% of their typically developing sample produced the target cluster accurately. The age of mastery ranged from 3;6 years (for /tw, kw/) to 8;0 years for later developing three-element clusters (/spr, str, skr/), with most clusters being mastered by the age of 7;0 years.

Word-final clusters have been reported to develop earlier than word-initial clusters for children learning English (Kirk & Demuth, 2005), German (Lleo & Prinz, 1996), and Dutch (Levelt, Schiller, & Levelt, 1999-2000). This is opposite to the development of singleton consonants which generally develop in word-initial position first.

Kirk and Demuth (2005) reported on the production of consonant clusters in 12 children from English-speaking backgrounds aged from 1;5-2;7 years. The proportion of correctly produced word-final clusters for this group of young children was much higher than for word-initial clusters. The most accurate productions were for word-final nasal + /z/ (85% correct), word-final stop + /s/ (79% correct) and word-final nasal + stop (57% correct) consonant clusters. Results showed that 11 of the 12 participants were producing nasal + /z/ and stop + /s/ word-final clusters accurately more than half of the time. The word-initial clusters with the highest accuracy were 50% for stop + /l/ clusters and 45% /s/ + stop clusters. Results were similar for a German study reported by Lleo & Prinz (1996) and a Dutch study reported by Levelt

et al. (1999-2000). The participants in both of these studies accurately produced word-final clusters before word-initial clusters.

In contrast to the above studies McLeod et al. (2001a) reported that the earliest emerging clusters for most of their participants were word-initial rather than word-final. However, word-final morphologically complex clusters were excluded from this study, reducing the number of word-final clusters attempted. The authors also reported that there were less stimuli items to elicit word-final clusters than word-initial. These factors may have impacted on their results for word-final cluster production.

1.1.5.1.1 Stages of cluster development

Children with typical development do not usually start attempting consonant clusters accurately. They often, but do not always, move through a number of stages before accurately producing consonant clusters. Early consonant cluster attempts often result in reduction of the number of cluster elements produced or in cluster element substitution/s (McLeod et al., 2001a; Smit, 1993). Greenlee (1974) described three stages of development of clusters in children with typical development in her review of seven previously published studies which reported on the production of stop + liquid consonant clusters. The cluster productions of all nine children from six different language backgrounds progressed through the same three stages. These were: Stage 1: Cluster reduction – by deleting the liquid element (e.g., /kr/ → [k])

Stage 2: Cluster substitution – by producing two elements but with a substitution for the liquid element (e.g., /kr/ → [kw])

Stage 3: Correct production – producing the stop + liquid cluster accurately

Smit's (1993) data supported these three stages of cluster acquisition and suggested that this pattern describes the acquisition of most consonant clusters, not only the stop + liquid clusters analysed by Greenlee (1974). Smit reported on the production of word-initial clusters for 1,049 children with typical development aged between 2 and 9 years old involved in the Iowa-Nebraska Articulation Norms Project. The youngest children in the study demonstrated cluster reduction, older children produced two element clusters but with one or more cluster elements in error, and the oldest children presented with correct cluster production. The three basic stages of cluster development are discussed in detail below.

Stage 1. Cluster reduction

The first stage, cluster reduction, is commonly observed in early cluster production attempts for children with typical development. Cluster reduction occurs when “a sequence of two consonants in the target word is replaced by a single consonant in the child's production” (Vihman, 1987, p.521). By doing this, the speaker avoids having to produce two consonants together in the same syllable and the consonant + vowel syllable type which is easier for children to articulate is produced instead (Yavas, 1998).

Cluster reduction has been reported frequently in the speech of young children with typical development (Grunwell, 1982; Kirk, 2007; McLeod et al., 2001a, 2001b; Preisser, Hodson, & Paden, 1988; Smit, 1993; Velleman & Vihman, 2002). Vihman and Greenlee (2002) reported that children aged 12 –33 months presented with up to 100% cluster reduction for cluster attempts. Another study reported by McLeod et al. (2001a) assessed the consonant cluster production 2-year-old participants with typical development. They reported that cluster reduction occurred more often with the

younger children in this sample and an average of 32.5% of clusters were reduced to singletons in the speech samples in their study.

Cluster reduction is one of few persistent error patterns found in children with typical development. Preisser et al. (1988) reported that the only three phonological processes occurred more than 40% in the single word productions of their 20 participants aged 1;10 to 2;1 years. These were cluster reduction, liquid deviation and stridency deletion. By the age of 2;5 years their participants demonstrated only two phonological processes more than 25% of the time, cluster reduction and liquid deviation. These studies indicate that while most sounds have developed in the speech of children as young as 2;6 years, the production of cluster sequences continues to be difficult.

The cluster reduction process is used less as children get older. Preisser et al. (1988) reported that 93% of clusters were reduced for their normative sample when aged 1;6 - 1;9 years, but that this decreased to a mean of 53% cluster reduction for participants aged 2;2 - 2;5 years. Grunwell (1982) also reported a decrease in cluster reduction as children get older. She stated that cluster reduction is almost always present until a child is 2;6 years old, but that the process almost non-existent by the time children are aged 3;8 years. Similarly, both Smit (1993) and Hodson and Paden (1981) reported that cluster reduction was rare in the production attempts of their 4-year-old participants with typical development, despite being one of the last phonological patterns to be eliminated.

Cluster reduction often involves deleting one or more of the elements of a cluster and retaining only one of the cluster elements (e.g., /tr/ → [t]), but a cluster may also be reduced to a singleton which is not an element of the target cluster (e.g., /gr/ → [d]). Patterns for the way different types of cluster are reduced have been

observed (Smit, 1993). Smit (1993) reported rules for which sound is likely to be preserved with different types of cluster when reduced by typically developing children based on the data from the Iowa-Nebraska Articulation Norms Project. The typical cluster reduction errors were:

- Reduction to the first element (or a substitution for it) for consonant + /l, r, w/ clusters (e.g., /fr/→[f], /kw/→[k], /sl/→[s])
- Reduction to the second element with /s/ + consonant /w, m, n, p, t, k/ clusters (e.g., /st/→[t], /sk/→[k])

These typical errors were based on detailed results with percentages of error types presented for each word-initial cluster type with participants grouped into four age bands. For example, 2 to 3-year-old children produced the cluster /pl/ accurately 23% of the time, reduced to [p] 15-50% of the time, and reduced to [l] less than 3% of the time. Similar reduction patterns were found by Vihman and Greenlee (2002) in their study of 10 children with typical development at age 3 years.

Stage 2. Cluster substitution

Developmentally, cluster reduction is often followed by cluster substitution where the correct number of elements is retained, but one or more consonants in the cluster is produced incorrectly (e.g., *green* produced as [gwin] or *plane* produced as [fre□n]). Smit (1993) reported that most children with typical development produced the correct number of consonants for clusters by the age of 4 years, with substitution errors continuing beyond this age. The most common substitutions seen in children with typical development are where the liquid consonants /r/ and /l/ are realised as the glides /w/ and /j/ (e.g., *glue* produced as [gju] or [gwu] and *frog* produced as [fw□g]; McLeod et al., 2001b).

A substitution error in a cluster frequently reflects the child's production of a phoneme as a singleton (Bernthal & Bankson, 2004; Smit, 1993). Smit (1993) stated that children who preserve the number of elements of a cluster but make substitution errors (especially those that reflect their production of singletons) should be credited with the production of the correct number of segments. Their normative sample data suggests that children manage consonants the same way in a cluster and as a singleton. This view was also taken by Kirk and Demuth (2005) who scored productions as correct if the substitution of a cluster element could be predicted by the child's production of the phoneme as a singleton.

Kirk (2007) reported on the types of substitution errors made by 11 participants with typical development aged 1;5-2;7 years. Of the substitution errors, 71% were predictable from the realisations of the elements of the cluster as singletons and 29% were unpredictable. Assimilation errors, where substitution results in both cluster elements having the same place or manner of articulation, accounted for more than two-thirds (69%) of the unpredictable errors. This suggests that difficulty articulating two phonemes together in a cluster when they have different place or manner of articulation is the cause of more than one-fifth of cluster substitutions.

Stage 3. Correct cluster production

The final stage of development is for the consonant cluster to be produced in the adult form. McLeod et al. (2001a) reported on the cluster production development of two-year-old children with typical development. Their cluster attempts were examined monthly over a period of 6 months. All 16 of the 2-year-old participants correctly produced a number of consonant clusters during the study. The youngest of these children produced few or no consonant clusters correctly during initial speech samples. For example, Participant 1 produced only one target cluster accurately when

assessed at age 2;1, but produced six accurate clusters when assessed at age 2;5. The older children in the study correctly produced more consonant clusters than the younger children.

Stoel-Gammon (1987) also reported on accurate cluster production for 2-year-old participants with typical development. Of the 33 participants aged 24 months, 48% accurately produced at least two word-initial consonant clusters and 58% accurately produced at least two word-final consonant clusters.

Dyson (1988) reported that by age 3;3 years, an average of 10.7 distinct word-initial and 7.7 word-final consonant clusters were produced by their participants with typical speech development.

These three stages of development of consonant clusters (i.e. cluster reduction, cluster substitution, and correct cluster production) describe the most common route of acquisition for children with typical development. Children may not move through all of these stages for all clusters. In addition, they may be at different stages for different cluster types (e.g., a child may be reducing /s/ clusters but producing plosive + liquid clusters with substitution errors).

1.1.5.1.2 Other non-adult productions

Although cluster reduction and cluster substitution are the most common non-adult productions of consonant clusters, other non-adult realisations also occur in the production attempts for children with typical development. For example, cluster reduction and substitution were reported for all of the children reported in Greenlee's (1974) review of studies of consonant + liquid cluster development in children with typical development with several other non-adult realisations of clusters were also reported for some participants only. These included deletion of the entire cluster, epenthesis, and metathesis. Examples of these error types are *drum* produced as [□m]

for deletion, *blue* produced [bəlu] for epenthesis, and *desk* produced [dɛks] for metathesis. Not all children produce these error patterns in and they are generally short lived for children with typical development.

Cluster deletion

Although the deletion of both elements of a cluster is not common for children with typical development, some researchers have reported that children aged 1-3 years occasionally delete consonant clusters (Greenlee, 1974; Hodson & Paden, 1981; Smit, 1993). For example, Smit (1993) reported that between 1% and 4% of the production attempts for word-initial /kl/ and /gl/ and less than 1% of attempts of /sl, tw, sm/ were deleted by the 2 to 3-year-old participants in the Iowa-Nebraska Articulation Norms Project. No other clusters were reported to be deleted by this age group and no data was presented suggesting that clusters were omitted by children aged 3 years and older.

Epenthesis

Epenthesis occurs when two elements of a cluster are separated by adding a vowel. Epenthesis, particularly the insertion of the schwa, has been reported in the speech of children with typical development when aged 2 to 8 years old as they attempt productions that preserve two members of a consonant cluster (e.g., *great* becomes /gəret/; Greenlee, 1974; McLeod et al., 2001b; Smit, 1993). Smit (1993) reported that epenthesis occurred most commonly for consonant + liquid clusters and was very rare with /s/ clusters. Productions with the insertion of a schwa between cluster elements were given credit in the Iowa-Nebraska Norms Project as this can occur with emphatic pronunciation in adult speech (e.g., *please* produced as /pəliz/) and because the schwa can be interpreted as a lengthened transition from a consonant to a sonorant element rather than a true vowel insertion (Smit, 1993). The insertion of

any other vowel was scored as an error and occurred very rarely. Schwa epenthesis was more common in the production attempts for the younger children than for older participants in this study. Kirk and Demuth (2005) also analysed insertion of schwa between cluster elements as correct, but productions with the insertion of other vowels were coded as errors.

Metathesis

Metathesis occurs when the elements of a consonant cluster are reversed (e.g., *desk* produced as [dɛks]). This is relatively rare and is generally only seen with word-final and medial cluster attempts which contain the phoneme /s/ (Hodson & Paden, 1981; McLeod et al., 2001a, 2001b). Hodson and Paden (1981) reported that 15% (9/60) of their 4-year-old participants with typical development used metathesis on at least one occasion in their study.

Coalescence

Coalescence is the term used to describe the realisation of a two-element cluster as a single-element, which combines features of both elements (e.g., *spoon* produced as [fun], combining the frication from the /s/ and labial place of articulation from the /p/; Chin & Dinnsen, 1992). This appears to be an intermediate stage between producing the cluster as a single element and retaining two elements, as the realisation is a mixture of both cluster elements. This is not a common realisation, but may appear when a child first begins to produce some two-element clusters. Chin and Dinnsen (1992) reported that coalescence most commonly occurs with /s/ clusters realised as [f] where the second element is a labial consonant (i.e. /sp, sw, sm/).

1.1.5.1.3 Summary

The data presented in the preceding section illustrates that children with typical development commonly have difficulty producing consonant clusters in the early stages of speech acquisition. Most children move through the three stages described above while acquiring their consonant clusters. They tend to move through these stages at different times and rates for different types of cluster. Despite being one of the most persistent phonological processes seen in the speech of children with typical development, by the time they are 3 years old they are generally able to produce a number of consonant clusters in the adult form, with the majority of error clusters produced with substitution errors rather than reduced to a singleton phoneme. It is important to keep this normative data for the age and order of acquisition for consonant clusters in mind when considering the cluster production attempts of children with speech sound disorder.

1.1.5.2 Disordered cluster development

Children with speech sound disorder frequently have difficulty producing consonant clusters (Chin & Dinnsen, 1992; Hodson & Paden, 1981; McLeod et al., 1997; Powell & Elbert, 1984; Stoel-Gammon, 1987). Their difficulty with production of consonant clusters generally persists until long after their age-matched peers with typical development are accurately producing clusters (Hodson & Paden, 1981; Wyllie-Smith et al., 2006).

Cluster reduction is often a late process for children with speech sound disorders to eliminate, resulting in persisting cluster production difficulties after the age that children with typical development would generally have achieved adult-like cluster productions. Wyllie-Smith et al. (2006) demonstrated this when they compared the cluster production of 40 participants with speech sound disorder aged 3;6- 5;8 with the productions of 16 participants with typical development aged 2;0-2;11 years.

The children with speech sound disorder presented with 30.3% cluster reduction, which was relatively similar to the children with typical development (37.1% cluster reduction) who were much younger. Hodson and Paden (1981) looked at the cluster productions of children with speech sound disorder with an older sample of children with typical development than Wyllie-Smith et al. (2006). They compared the speech productions of 60 participants with unintelligible speech aged 3-8 years and 60 participants with typical development aged 4 years. Cluster reduction was reported very rarely for the 4-year-old children with typical development, but for 100% of the 4 to 5-year-old participants with speech sound disorder.

Research into the cluster acquisition of children with speech-sound disorder has suggested that accurate production of consonant clusters may not occur without specific intervention targeting both articulatory production and phonological awareness of the structure of consonant clusters (Hodson, Scherz, & Strattman, 2002). This means that children may need to have explicit instruction to show that clusters are made up of two sounds that are produced together, as well as being given opportunities to practice their production.

1.1.5.2.1 Error types for children with speech sound disorder

The usual cluster error productions for children with speech sound disorder have been described by Chin and Dinnsen (1992) and McLeod et al. (1997). These include both typical realisations, which are commonly seen in children with typical development, and atypical cluster realisations, which are either infrequently used or never seen in the speech of children with typical development.

1.1.5.2.2 Typical cluster realisations by children with speech sound disorder

Many errors produced by children with speech sound disorder are similar to those seen in younger children with typical development (see descriptions of typical reduction, substitution and other non-adult error patterns above) (Chin & Dinnsen, 1992; McLeod et al., 1997). Chin and Dinnsen (1992) reported on the cluster productions of 47 participants with speech sound disorder aged 3;4-6;8 years. They compared the word-initial cluster productions of their participants to data from typical acquisition literature and concluded that the error patterns used by their participants with speech sound disorder were generally similar to those used by young children with typical development. Their participants generally reduced clusters to the same elements as seen in normal acquisition data and substituted the same elements in clusters with substitution errors.

McLeod et al. (1997) described the order of acquisition of consonant clusters for children with speech sound disorders. The cluster production attempts of 40 participants with speech sound disorder aged 3;6-5;0 years was reported. In this study, 80% (32/40) of participants accurately produced at least some of the 20 word-initial stop + consonant clusters and 55% (22/40) accurately produced at least some of the word-initial fricative clusters. From the accuracy results of their participants, they suggested the following sequence of cluster type acquisition from this data:

1. word-final nasal + consonant clusters (e.g., /nt, mp, ŋk/)
2. word-initial stop + consonant clusters (e.g., /tr, pr, gl/)
3. word-initial fricative + consonant clusters (e.g., /fr, sl, st, θr/)
4. word-initial three-element clusters (e.g., /str, spl, skw/)

The acquisition of word-final clusters before word-initial clusters in McLeod et al. (1997) is similar to the results of Kirk and Demuth's (2005) study for young children with typical development.

It is difficult to directly compare the order of word-initial cluster acquisition of children with speech sound disorder suggested in McLeod et al. (1997) to that of children with typical development (Smit, 1993) as the clusters are grouped in different ways by the authors of these two studies. Smit (1993) grouped clusters based on them having specific consonants as cluster elements (e.g., /s/ clusters, /l/ clusters, /r/ clusters), whereas McLeod et al. (1997) grouped the clusters by the manner of articulation of the first element of a cluster (e.g., fricative + consonant cluster, stop + consonant cluster). Despite these differences, the acquisition sequences for both studies suggest that in word-initial position, stop + consonant clusters develop before fricative + consonant clusters.

1.1.5.2.3 Atypical cluster realisations

Children with speech sound disorder are more likely to present with atypical errors in their cluster production attempts than children with typical development (Smit, 1993). Errors that could be considered atypical are:

Error type 1: reduction of a cluster by deleting the typically retained element

Error type 2: reduction to a non-target singleton

Error type 3: cluster deletion

Error type 4: variability of cluster realisation

If a child with typical development presents with an atypical error, they generally use this for a restricted group of words and only for a short time, whereas children with speech sound disorder tend to use these atypical error patterns more consistently across sound groups and for a longer time-frame (Stoel-Gammon, 1991).

Error type 1: Deleting the typically retained cluster element

This involves reduction of a cluster by deleting a cluster element that would generally be retained by children with typical development (e.g., reduction of *stop* to

[sɪp] instead of /tɪp/). Hodson and Paden (1981) reported that some of the older children with speech sound disorder from their 3- to 8-year-old sample reduced /s/ clusters by retaining the /s/ and omitting the other element. This was usually with children who had received intervention for their speech, and may reflect treatment effects of targeting /s/ in isolation.

Error type 2: Reduction to non-target singleton

This involves reduction of a cluster to a consonant that is not an element of the target cluster. This consonant may, or may not, be predictable from the child's singleton productions of the cluster elements (i.e., /kl/ realised as [f] is unpredictable but /kr/ realised as [t] may be predictable if the child is fronting velar consonants). This is less common in the cluster reductions of children with typical development.

Wyllie-Smith et al. (2006) reported that 39% (200/509) of the clusters realised as singleton elements by their participants were produced as consonants that were not a cluster element. McLeod et al. (1997) also reported that a high proportion non-target reduction with 49% (342/702) of reduced cluster attempts realised as substituted consonants. These productions were not analysed to determine if these substituted consonants were unpredictable or predictable substitutions (e.g., realisations that reflected the participants' productions of the cluster elements as singletons or singletons resulting from coalescence would both be predictable substitutions).

Reduction to a non-target consonant, even those that are predictable from singleton production, increases the difficulty of interpretation for the listener as they have to take into consideration both the reduction and substitution in order to decipher the target cluster.

Error type 3: Cluster deletion

While cluster deletion is relatively rare for typically developing children (Greenlee, 1974; Hodson & Paden, 1981; Smit, 1993), it is more common for children with speech sound disorder. Hodson and Paden (1981) reported that around 50% of their 60 participants with speech sound disorder aged 3-8 years demonstrated some cluster deletion compared to only 15% of their 4-year-old participants with typical development. McLeod et al. (1997) reported that no word-initial clusters were deleted by their 40 participants with speech sound disorder aged 3;6-5;0, however word-final consonants were more commonly deleted. Word-final cluster deletion occurred in the production attempts of 17.5% (7/40) of the participants in this study. This was a much smaller proportion than in Hodson and Paden's (1981) study, but still much more common than children with typical development.

Error type 4: Variable cluster realisation

Children with speech sound disorder have been reported to demonstrate greater variability in their realisations of consonant clusters than children with typical development (Chin & Dinnsen, 1992; McLeod et al., 1997; Wyllie-Smith et al., 2006). That is, a single cluster is attempted with several different realisations (e.g., /kl/ realised as [k, l, j, gj, gl, kj]). It has been suggested that variability in cluster realisation may be an indication of unstable cluster representation in a child's phonological systems (Wyllie-Smith et al., 2006).

1.1.5.2.4 Summary

Research has shown that consonant cluster acquisition is almost always a difficult and slow process for children with speech sound disorder. They are also much more likely to present with atypical realisations of clusters than children with typical development, which adds to listeners' difficulty interpreting their speech. Although children with typical development move through a number of stages when acquiring clusters, they move through these stages relatively quickly and in a reasonably predictable manner. Children with speech sound disorder take much longer to move through these stages. Research has shown that without targeted intervention, inaccurate consonant cluster production persists until long after children reach school age, when these difficulties can impact on literacy development. For these reasons, it is important to consider providing intervention with clusters as targets for young children with speech sound disorder.

1.1.6 Types of intervention

There is both research-based and clinical evidence that intervention is beneficial for children with speech sound disorders (Crosbie et al., 2005; Gierut, 1998b; Gillon, 2005; Hodson, 2007). There are a number of different types of intervention which aim to improve the accuracy of speech production and/or phonological awareness for children with speech sound disorder. Despite the differences among children with speech sound disorder, something all intervention programmes have in common is their aim to improve speech intelligibility.

According to Dodd (2005) therapy for children with speech sound disorders should aim to:

1. facilitate correct articulation of mispronounced speech sounds

2. develop underlying conceptual representations for these speech sounds and the ability to access and process these representations.

Due to the heterogeneity of the population of children with speech sound disorders, there is unlikely to be one single treatment programme that will be effective for all children with speech sound disorders. This was demonstrated by Dodd and Bradford (2000) when three different therapy techniques (phonological contrast, core vocabulary, and PROMPT) were trialled with each of three participants. The phonological contrast therapy worked well when a child had consistent non-developmental errors in their speech, but was not as effective for a child with inconsistent errors. Although based on a small group of single case studies, these findings suggest that there is unlikely to be one cure-all intervention programme.

Many treatment efficacy studies have looked at improvement by comparing measures of Percentage of Consonants Correct (PCC) and other overall intelligibility measures pre- and post-therapy for children with speech sound disorder (e.g., (Gierut, 1998b; Gillon, 2005; Tyler et al., 2002). Some efficacy studies have also included more specific information about their participants' speech. For example, phonological inventories, phonological process use, inconsistent productions (Crosbie et al., 2005; Dodd & Bradford, 2000; Tyler, Lewis, & Welch, 2003).

To date, efficacy studies for the two intervention programmes used in the current study have reported on the impact of intervention on children's overall phonological system (Gillon, 2000; Gillon, 2005; Tyler et al., 2002), but do not describing specific areas of speech development.

1.1.6.1 Phonological awareness intervention

Children with speech sound disorder often present with associated phonological awareness difficulty and, as they get older, with literacy problems

(Rvachew & Grawburg, 2006; Stackhouse et al., 2002). Gillon (2002) reported that children with a history of speech sound disorder, even if speech errors have resolved, are still likely to have poorer phonological awareness skills than children with typical development.

Phonological awareness intervention has been developed to help children with early literacy difficulties. However, research has shown that phonological awareness training also improves the accuracy of speech sound production (Gillon, 2000). Gillon has developed a programme which integrates speech production goals into phonological awareness training for use with children at preschool and early school age (Gillon, 2004; 2005). This programme incorporates phonological awareness intervention with speech sound targets for preschool children aged 3-4 years. Intervention provided in intensive blocks (two hours a week for 6-8 weeks) for two blocks of therapy per year is recommended.

In an efficacy study for use of this programme with children in their early school years (i.e. aged 5;6-7;6 years), Gillon (2000) reported that the 23 participants who received phonological awareness intervention had improved phonological awareness skills and speech production. This improvement was greater than for the 23 children who received traditional speech-language therapy input and the 15 participants who received minimal input during the study. The phonological awareness skills of the children who received the phonological awareness training were similar to their typically developing peers when assessed post-intervention.

In another longitudinal efficacy study, Gillon (2005) reported on the speech, phonological awareness and early literacy development of 12 participants with speech sound disorder who were aged 3-5 years when they received intervention. The data from this study showed that the preschool children had improved speech production

and phonological awareness following intervention. Follow-up in the early school years showed that the intervention for phoneme awareness and letter knowledge during preschool intervention resulted in early literacy performance comparative to their typically developing peers. The participants also performed better on complex phonological awareness tasks and measures of reading and spelling ability than children with speech sound disorder who had not received the integrated phonological awareness and speech intervention.

1.1.6.2 Morphosyntactical intervention

Children with speech sound disorder often present with concomitant language difficulties. Tyler (2002) reported that morphosyntax difficulty is commonly seen for children with speech sound disorder, and that most estimates in the literature suggest a co-occurrence of 40-60% for children up to 6 years old who present with either disorder. Generally, intervention programmes provide therapy for either speech or language difficulties, one at a time. It is of interest to practitioners to know if they should first target the speech or language difficulties in order to facilitate the greatest and most rapid improvement for their clients.

Tyler et al. (2002) reported on an intervention efficacy study for intervention which provided therapy for both morphological awareness and speech targets. The aim of using these two types of intervention was to improve both expressive language (especially grammatical morpheme use) and speech intelligibility. Ten preschoolers with speech and language impairment aged 3;0-5;1 years had intervention with a block of morphosyntactical therapy (Haskill et al., 2001) followed by a block of traditional speech intervention, or vice versa. Both traditional speech intervention and morphosyntactical intervention facilitated improvements in the targeted area when compared to a control group. However, Tyler et al. (2002) reported that children who

had the morphosyntactical intervention first had the greatest improvements in both speech production and morphosyntax.

In a later study, Tyler et al. (2003) compared the speech and morphosyntax productions of 40 children with speech and language impairment aged 3;0-5;11 years following intervention. Outcomes were compared for four different ways of providing intervention. In the first and second, intervention was provided in 2 blocks, with one group starting with the phonology block first and the other with the morphosyntax block. In the third group intervention was provided with morphosyntax and phonological targets alternated weekly. In the final group, morphosyntax and phonological targets were treated in each session. The greatest change for morphosyntactic use was seen for the children with weekly alternating targets, and phonology improvements were similar for all four intervention groups.

Intervention was provided in this study with alternating weeks of morphosyntax intervention with a week of traditional speech intervention. Each morphosyntax target and each speech target is presented in cycle 1 of intervention, and then the targets are revisited in cycle 2. In a cycles approach a certain level of mastery is not required before a new target is introduced, and a specified amount of intervention is provided for each target during every cycle. The cycles approach was reported by Hodson (2004) as more closely aligned with the way a typically developing child acquires speech and language than teaching single phonemes or language structures to a level of mastery one at a time.

Tyler (2002) recommends a language-based approach to intervention for children with both speech and language difficulties. In Tyler et al. (2002) gains were reported in both expressive language and speech production following the morphosyntax intervention. Tyler (2002) also reported that this intervention,

presented in the context of conversation, focuses on the use of speech for communication, rather than presenting speech targets in a drill context.

1.1.6.3 Efficiency of interventions

Gierut (1998b) reported that most studies investigating treatment efficacy have addressed the effect of different intervention types on target sounds and the amount of generalisation to non-target sounds. Comparatively few studies have looked at treatment efficiency. That is, comparing different types of treatment with each other to determine if one results in greater or faster improvement than another (Crosbie et al., 2005; Dodd & Bradford, 2000).

For this reason, Gillon, Tyler and Schwarz (2007) devised a treatment efficacy study to evaluate and compare the integrated phonological awareness and speech intervention (described in Gillon & Moriarty, 2005) and the alternating morphosyntax and speech programme (described in Haskill et al., 2001) that have been developed for children with speech sound disorder. The participants for the study reported in this thesis were recruited from the participants in this larger efficacy study.

In previous efficacy studies for these two intervention programmes, the authors have reported pre- and post-intervention PCC scores to show evidence of improved speech production. Although information has been provided about other aspects of the participants' language outcomes following intervention using these two programmes (e.g., phonological awareness, early reading outcomes, expressive language, and vocabulary), the impact of intervention on specific areas within their participants' phonology has not been reported. The specific area of speech acquisition addressed in the study reported in this thesis is the development of consonant clusters. Improvements towards accurate production during the development of consonant clusters can be described more specifically than the acquisition of singletons due to

the different stages of development and extended time taken to acquire clusters (McLeod et al., 2001b). This makes consonant clusters an interesting area to observe over the course of an intervention study. Many children with speech sound disorders do not develop correct production of consonant clusters without intervention until well after they start school, and consideration of which clusters are the most appropriate targets for these children is required.

1.1.6.4 Rationale for clusters as targets for children with speech sound difficulty

There is much support in the literature for selecting consonant clusters as speech targets for intervention. Smit (1993), Hodson (1991) and Gierut (2001) are three advocates for intervention for cluster targets. Smit (1993) stated that “clinicians need to attend to consonant cluster production as well as to production of consonant singletons, at least for children beyond the early word-learning stage of phonologic development” (p. 945) because of their importance in English phonology and the impact that cluster reduction has on intelligibility. Hodson (1991) reported that “consonant sequence reduction has been the most prevalent phonological process that differentiates utterances of clients with highly unintelligible speech from speech samples of their normal peers” (pp. 39-40). According to Hodson et al. (2002) cluster reduction is one of the phonological processes that persists beyond preschool years in the speech of children who are unintelligible if intervention is not provided (the other process was gliding of liquids). Hodson (1991; 2007) reported that the inability to produce clusters can impact on intelligibility in connected speech because unintelligible children have difficulty producing the consonant sequences that are created when words are produced closely together. In connected speech, consonant

sequences are created across syllables (e.g., /θd/ in *birthday*) or across word boundaries (e.g., /sp/ in *nice puppy*) as well as those which already occur within words. This provides an explanation for the deletion of word-final consonants that is commonly seen in connected speech (i.e. the child is reducing consonant sequences which cross word boundaries).

Gierut and colleagues (Gierut, 1998a; 2001; Gierut & O'Connor, 2002) reported that targeting consonant clusters in intervention results in greater generalisation to untreated sounds and clusters than when singletons are treated.

There are two main approaches to selection of intervention targets:

1. developmentally-based
2. complexity-based

The developmental approach has been used traditionally in speech-language therapy. Normative data for order and age of acquisition are used as guidelines for target selection. The speech target selected is the next phoneme the therapist would expect to develop when looking at developmental charts and comparing to what the child already has in their phonetic inventory (Bernthal & Bankson, 1998; Kahmi & Pollock, 2005).

The complexity approach suggests that later developing or more difficult sounds should be targets. Sounds that are usually earlier to develop are expected to improve due to the acquisition of the more complex sounds. These targets are generally more complex to articulate, but are selected based on the child's underlying phonological knowledge of the sounds. Williams (1991) reported that variability and stimulability for production of a sound are evidence that a child has phonological knowledge of a sound compared to sounds that are absent from their phonetic inventories.

There is much discussion of the advantages of using these two contrasting methods of target selection in the literature. Targets are selected for opposite reasons using the different approaches. Developmentally based target selection involves selecting early developing, stimutable sounds that the child has the most knowledge of, as these sounds are likely to be easier for the child to learn. In contrast, complexity based target selection involves selecting targets that are later developing and that the child has least phonological knowledge of, as these sounds are expected to result in greater system-wide change in the child's phonology following intervention (Kahmi & Pollock, 2005).

There is research which shows that both developmentally-based and complexity-based target selection result in improved speech production accuracy (Gierut, 1998a; Miccio & Ingrisano, 2000; Powell & Elbert, 1984; Rvachew & Nowak, 2001; Williams, 1991). However, the speech-language therapy profession is striving to provide evidence of not only effectiveness but also efficiency of treatment methods. Interventions need to be evaluated not only for the amount of impact they have on the targets of intervention, but also for the amount of generalisation which occurs within and across class. Within class generalisation is transfer of correct target production to untrained positions (e.g., producing the target word-initial /k/ in word-final position in *back*) and/or improved production of other sounds affected by the same error pattern (e.g., improved production of the fricative /f/ when /s/ is an intervention target if both were effected by the phonological process stopping) (Kahmi & Pollock, 2005). Across class transfer refers to the correct production of untreated sounds from different sound classes than the target sound. For example, improved production of word-final /s/ when word-final plosives are treated (Kahmi & Pollock, 2005).

There is evidence that greater system-wide change occurs when targets for intervention are phonologically complex than when speech targets are comparatively early developing (Elbert, Dinnsen, & Powell, 1984; Gierut, 1998a; Gierut & O'Connor, 2002; Miccio & Ingrisano, 2000; Powell & Elbert, 1984; Williams, 1991).

Powell and Elbert (1984) have reported that treating later developing consonant clusters results in greater generalisation than treating earlier developing consonant clusters. In Powell and Elbert (1984) intervention outcomes for six participants with speech sound disorder aged 4;4-6;3 years are reported. Treatment involved instruction for either the stop + liquid clusters /tr, gr, bl/, or the fricative + liquid clusters /fr, □r, sl/. Generalisation following intervention was compared for earlier developing stop + liquid clusters versus later developing fricative + liquid clusters as speech targets. There was greater improvement in untreated cluster types for participants who had the later developing fricative + liquid clusters as speech targets. Both groups had improvement within their target cluster groups. These data suggest that targeting later developing clusters will result in greater improvement in cluster production.

Gierut and Champion (2001) reported on another study that looked at generalisation post-intervention for late developing clusters. Intervention was provided to eight children with speech sound disorder aged 3;4 to 6;3 years. In this study a three-element cluster was selected as a target for each participant. The participants were unable to produce any word-initial clusters pre-intervention. Results showed generalisation to a range of untreated singletons, (including untreated affricate phonemes), and to two-element consonant clusters. Improved production of the target three-element clusters was not maintained post-intervention. This research

supports the complexity approach for target selection as improvements were seen across participants' sound systems.

In contrast however, Ravchew and Nowak (2001) found differing results when comparing developmental- versus complexity-based target selection. They looked at the speech of 48 preschool children with speech sound disorder following intervention for targets selected either on a developmental basis or to represent least phonological knowledge. They found similar generalisation patterns for either method of target selection, but greater within class improvements for the developmentally selected targets. This study addressed singleton consonants as targets and so may not be compared directly to the studies that targeted consonant clusters, but this suggests that further large-scale efficacy studies are required to address the issue of target selection.

1.1.6.5 Rationale for the cluster targets in the current study

Two different cluster types were selected as targets for the children in the current study. These were word-initial /s/ clusters and word-final morphologically created clusters. The selection of these clusters as targets reflected the theory behind the two intervention approaches used in the therapy.

The phonological awareness with integrated speech targets intervention (Gillon & Moriarty, 2005) aims to increase speech production, phonological awareness, and early literacy skills in the preschool children approaching school age. Targeting the /s/ consonant clusters /st, sp, sl/ in this intervention programme:

- introduces the concept of producing two sounds together
- provides production practice for the /s/ clusters and the individual consonants that make up the clusters (i.e., /st, sp, sl, s, t, p, l/)
- introduces the names and sounds for some of the most commonly used letters in English (i.e., s, t, p, l)

- provides visual reinforcement through writing for the structure of consonant clusters
- emphasises the phonological awareness of the structure of clusters using written and spoken activities where cluster elements are deleted and replaced

The morphosyntax intervention alternating with articulation therapy (Haskill et al., 2001) aims to improve expressive language and speech production by increasing awareness of common morphemes and through intervention for specific error sounds and/or patterns. Targeting word-final morphologically created clusters using this programme:

- demonstrates that many word-final clusters hold morphological information
- ensures practice opportunities for word-final targets (focus is on attempting the morpheme not correctly pronouncing the clusters)
- introduces the clusters and then revisits them in the next cycle of therapy to help build on the understanding and use of the morphemes

Further support for the selection of these clusters as intervention targets is provided in this section.

1.1.6.5.1 Rationale for targeting /s/ clusters

Different rationales for targeting /s/ clusters in intervention have been proposed in the literature. These include:

- generalisation patterns following intervention
- difficulty producing /s/ in the context of clusters despite accuracy for singleton productions
- the impact that inaccurate /s/ cluster production has on intelligibility

These will now be discussed in more detail.

Generalisation patterns

Following intervention for /s/ clusters, generalisation has been seen for singleton /s/ and other fricative phonemes in isolation. Gierut (1999; 2001) reported that /s/ cluster intervention resulted in improved production of fricative and affricate singletons. This generalisation pattern is important as the singleton /s/ occurs frequently in English words and is used to indicate the morphological information for plurals, possessives and for third person singular verbs (Hodson, 2007). Despite improvements in singleton fricative and affricate sounds, Gierut's (1999; 2001) data do not support the selection of two-element /s/ clusters as a way to promote development of consonant clusters. She found greater generalisation to two-element clusters when targeting the later developing three-element clusters in intervention than when providing intervention for two-element /s/ clusters (Gierut & Champion, 2001).

Hodson (1991) suggested that targeting /s/ clusters simultaneously targets the production error processes of cluster reduction and stridency deletion (i.e. the child says [tænd] for the words *stand* and *sand*). She reported that in her clinical experience, the children who present with both of these phonological processes are the least intelligible. Hodson and colleagues (1997; 2004) reported that it is easier for children to produce /s/ followed by a /t/ rather than replacing the /t/ with /s/ for these children (e.g., the singleton /s/ is targeted and the child continues to produce the stop /t/ as well as the newly introduced /s/ (*sun* is pronounced [st□n])).

Difficulty producing /s/ in the context of clusters without intervention

Hodson and Paden (1981) reported that the older participants (aged 7-8 years) in their group of children with speech sound disorders often presented with reduction of /s/ clusters through deletion of the /s/ element, despite being able to produce the

singleton /s/ accurately. Hodson (2007) also observed that children with speech sound disorder who have had intervention for the singleton /s/ sometimes reduce /s/ clusters by deleting the element which is usually retained and producing the /s/. Both of these observations suggest that children with speech sound disorder may not use /s/ in the context of clusters despite being able to use produce it as a singleton, therefore specific instruction for production within consonant clusters may be necessary.

Impact on intelligibility

Hodson (1991; 2007) also reported that she has found that targeting /s/ clusters has helped with intelligibility, as the production of cross-syllable and cross-word consonant sequences improves. As no controlled research studies have confirmed this finding, there is a need for further investigation of the impact of targeting consonant clusters in intervention.

1.1.6.5.2 Rationale for targeting morphologically created word-final clusters

The reasons behind targeting word-final clusters which are created when morphemes are added to the end of words include:

- the frequency that children hear and attempt word-final clusters
- the meaningfulness of the target

Frequency of occurrence

As reported earlier, studies of the vocabularies of young children have indicated common use of consonant clusters. For example, Beukelman et al. (1989) reported the 250 most commonly used words from a corpus elicited from 6 children with typical development. Of these 250 words, 16% had consonant clusters at the word edges, and 60% of these clusters were word-final consonants. When speech targets occur with high-frequency in children's vocabulary they have more

opportunities to practice target sounds, increasing the likelihood of generalisation to accurate production in connected speech.

As reported by Kirk and Demuth (2005) two-thirds of the word-edge consonant clusters heard by children are in word-final position. A large proportion of these are likely to be nasal + /z/ or stop + /s/ clusters which are the types of clusters often created when adding word-final grammatical morphological structures to words.

Despite the predominance of word-final clusters heard and attempted by young children, many children with speech sound disorder show poor accuracy on word-final consonant clusters. This suggests that more specific training is required to develop these clusters beyond hearing them in the ambient language.

Meaningful targets

Stoel-Gammon (1987) suggested that generalisation is most likely to occur when the sounds targeted are used meaningfully in therapy. This supports the argument that increasing the awareness of the morphological aspects of many word-final clusters may help to increase generalisation following intervention. The child is taught that producing the cluster gives the word a different meaning. Increasing awareness and encouraging use of word-final morphological structures may result in improved production of the clusters as well as underlying knowledge of the morphemes.

If a word-final morphologically created consonant cluster is produced inaccurately by a child with expressive language difficulties and expressive phonological disorder, it may be due to poor understanding of the morpheme, difficulty producing the cluster, or a combination of both. Targeting these structures in an expressive language intervention ensures that a child is not only exposed to clear, repeated models of the structures, but is also expected to attempt the structures.

1.1.7 Current study

Consonant clusters are of interest as they commonly occur in English speech, take longer to acquire than other areas of phonological development, and are one of the areas that most frequently causes difficulty for children with speech sound disorder. Developing an understanding of the impact of intervention on cluster development is important, as several researchers have suggested that targeting clusters can lead to greater system wide change in children's phonologies than targeting singletons.

There is some conflicting support for treatment of /s/ clusters in the literature. Hodson (1991; 2007) has reported that selecting /s/ clusters as speech targets has improved not only the production of stridency in singletons, but also awareness of the concept and production of clusters. However, Gierut's (1999) findings suggested that improved production of /s/ clusters may generalise to fricative singletons and affricates, but not to other cluster types (e.g., stop + /l/ or stop + /r/ clusters).

The intervention efficacy studies that suggest that consonant clusters are appropriate targets for intervention have focussed on therapy for word-initial clusters only. This may be due to the difficulty in knowing if a child is having difficulty understanding the morpheme or the cluster being attempted when words with morphologically created clusters are assessed. Tyler's research into the impact of morphological intervention on speech has not reported on accuracy for word-final clusters. The efficacy of intervention for word-final clusters is an area which has not been addressed in the literature, and appropriate ways of ensuring that both the language and the articulatory elements of word-final clusters need to be considered.

The current study aims to extend research in the acquisition of clusters through investigating the impact of different types of intervention on the cluster production of

a group of children with speech and language difficulties. Two different therapy techniques were compared to identify the impact they had on cluster production in different positions within words and across different classes of consonant clusters. The two therapy techniques differed in that cluster targets were word-initial for the phonological awareness therapy, and word-final for the morphosyntax therapy. The amount of change across clusters in both word initial and word final position was assessed.

As the acquisition process for consonant clusters generally involves moving through a number of stages over extended period of time, this process can be described more specifically than the acquisition of singletons (McLeod et al., 2001b). The results of McLeod et al.'s (2001a) longitudinal study, showed that only half of their 2-year-old participants with typical development showed increases in the percentage of accurate clusters during the 6 months that they were monitored, but all of the participants increased the number of non-adult cluster forms produced and showed movement towards accurate cluster production during this time. Reporting correct versus incorrect production as the only measure of improved cluster production will not identify these improvements towards more accurate production.

The current study aims to report on the changes in development of consonant clusters over an extended period of time as for McLeod et al. (2001a). In the current study the participants are older and have speech and language difficulties whereas McLeod et al. (2001a) studied the productions of 2-year-old children with typical development. The current study also reports changes following intervention, rather than observing for changes due to maturation.

The following hypotheses were tested:

1. That phonological awareness intervention that integrates the speech production goal of word-initial /s/ clusters will:
 - a) improve the production of the target /s/ clusters,
 - b) result in a transfer of skill production to other /s/ clusters that are not targeted in therapy, and
 - c) will result in improved production of singleton fricatives.
2. That language intervention that increases the awareness of word-final morphemes will improve the production of word-final clusters.
3. That providing opportunities to improve the production of singleton phonemes in both the phonological awareness and language interventions will result in improved production of these target sounds in the context of consonant clusters.

Chapter 2

Method

2.1.1 Participants

Six children with speech and language disorder participated in the study. The participants were selected during the recruitment stage of a treatment efficacy study being conducted by Gillon, Tyler, and Schwarz (2007), which investigates the efficacy of two types of treatment for children with speech and language disorder. The participants in the current study were aged between 4;6 and 4;11 at the start of intervention. All participants were monolingual speakers of New Zealand English, four were boys and two were girls. The participants were New Zealand European and attended preschools attached to schools which were classified by the New Zealand Ministry of Education as drawing upon a population with a mid to high socioeconomic status.

2.1.1.1 Inclusion criteria

The participants satisfied the criteria for inclusion in the larger efficacy study (Gillon et al., 2007). The participants' results for these inclusion measures are presented in Table 1. These criteria included evaluating participant performance on the following assessment measures:

2.1.1.1.1 *Speech measures*

- ***Goldman- Fristoe Test of Articulation***

The *Goldman-Fristoe Test of Articulation* (Goldman & Fristoe, 1972) consists of 35 pictures of objects and activities that are familiar to children. 44 responses are

elicited in relation to these pictures, with spontaneous productions where possible. This subtest elicits production attempts for the English consonant sounds in their most frequent positions and for 11 consonant clusters. Test-retest reliability of this subtest was assessed with repeated assessment by the same therapist. There was a median agreement of 95% (range = 81-100%) for presence or absence of error in production for each speech sounds, and 89% (range = 78-100%) for specific type of speech error (i.e. substitution, distortion, omission, addition or correct production) (Goldman & Fristoe, 1972). Inter-rater reliability was assessed with a median agreement of 92% (range = 62-100%) for presence or absence of error, and a median agreement of 88% (range = 62-100%) for type of production (Goldman & Fristoe, 1972).

- ***Diagnostic Evaluation of Articulation and Phonology (DEAP)***

Two subtests from the *Diagnostic Evaluation of Articulation and Phonology* (Dodd, Hua, Crosbie, Holm, & Ozanne, 2002) were used to assess the children's speech abilities. The Oro-motor Assessment and the Inconsistency Test were used to assess for apraxia of speech, a motor planning speech problem. The *Oro-motor Assessment* consists of three subtests, which assess the child's ability to accurately and quickly perform diadochokinetic, isolated and sequenced oral movements. The Inconsistency Test requires the child to produce 25 target words elicited with picture stimuli on three different occasions. The three productions of the same word are compared for consistency, with less than 40% variation considered to be within normal limits. Variations between a correct production and a developmentally age appropriate error are excluded from the inconsistency score. Normative data for the *Diagnostic Evaluation of Articulation and Phonology* (Dodd et al., 2002) is provided for children aged 3;6 years to 6;11 years. Test-retest reliability for the five subtests from this assessment ranged between .67 and .94, with test scores on all five measures

significantly correlated. Inter-rater reliability for the diadochokinetic movement subtest showed relatively low agreement (.387) reflecting the subjective nature of the scoring, however there was 80% or more agreement for diagnosis based on the oro-motor assessment (Dodd et al., 2002).

Children with a presentation indicating developmental apraxia of speech were excluded from this study. Inclusion criteria required the demonstration of a moderate or severe speech sound disorder as evidenced by a Percent of Consonants Correct (PCC) score below 70% on the combined speech measure. This included productions for the *Goldman-Fristoe Test of Articulation* sounds-in-words subtest (Goldman & Fristoe, 1972) and the children's first trial at the Inconsistency Test items (Dodd et al., 2002).

2.1.1.1.2 Language measures

- ***Structured Expressive Language Test – Preschool 2 (SPELT-P2)***

The *SPELT-P2* (Dawson et al., 2004) assesses a child's ability to produce a range of grammatical structures. A standard score between 85-115 is considered to be within normal limits for this assessment. The assessment contains 44 photographs of everyday situations or activities. The child is prompted to use a specific morphological or syntactical structure for each photograph by a scripted comment or question from the administrator (e.g., "The boy is not happy. Why?", "Tell me two things about this picture"). Normative data is provided for children aged 3 to 5;11 years. Measures of internal consistency had reliability coefficient ratings ranging from .80 to .88 for different age groups (Dawson et al., 2004). Test-retest reliability of the *SPELT-P2* is high with a test-retest correlation of .96 (Dawson et al., 2004). Inter-rater reliability was high with a correlation of .99 to 1.0 between two raters scoring 230 children's results (Dawson et al., 2004). Concurrent validity of the

SPELT-P2 was evaluated by comparing the assessment to the *Syntax Construction Test*, a subtest of the *Comprehensive Assessment of Spoken Language* (Carrow-Woolfolk, 1999). The correlation between the scores was reported as .86 suggesting the two assessments measure a similar construct (Dawson et al., 2004).

A standard score below 85 was required for study inclusion ($M=100$ for typically developing children, $SD=15$).

- Peabody Picture Vocabulary Test-Third Edition (PPVT-3)

The *PPVT-3* (Stoel-Gammon & Dunn, 1985) assesses a child's receptive vocabulary. Test items include nouns, verbs and adjectives. A child is required to identify a picture from a choice of four. The assessment is designed for use with children 2;6 years and older, and is made up of seventeen sets of twelve items. Normative data for populations aged 2;6 to 90;11 years is provided for this assessment. Measures of internal consistency had reliability coefficients ranging from .86 to .98 for the 25 standardisation groups (Stoel-Gammon & Dunn, 1985). Test-retest reliability of the *PPVT-3* is high with reliability coefficients of .91 to .94 (Stoel-Gammon & Dunn, 1985). The concurrent validity of the *PPVT-3* was evaluated by comparing the *PPVT-3* to measures of intelligence and language. This test correlated strongly (.91 to .92) to the verbal IQ subtest of the *Wechsler Intelligence Scale for Children – Third Edition* (Wechsler, 1991) when administered to children aged 7;11 to 14;4 years (Stoel-Gammon & Dunn, 1985). The assessment correlated less strongly (.63 to .83) to the *Oral and Written Language Scales (OWLS)* (Carrow-Woolfolk, 1995) when administered to children aged 3;0 to 5;8 years (Stoel-Gammon & Dunn, 1985). This was reported as an expected result as the *PPVT-3* assesses only receptive vocabulary and the *OWLS* is a comprehensive language assessment.

A receptive vocabulary standard score above 80 on the *Peabody Picture Vocabulary Test-3* (Stoel-Gammon & Dunn, 1985) ($M=100$, $SD=15$) was required to exclude children with more severe receptive vocabulary deficits.

2.1.1.1.3 Other exclusion criteria

Children with diagnoses of disorders such as Autism and Down Syndrome, Traumatic Brain Injury, or sensory loss were excluded from this study.

2.1.1.2 Further In-Depth Assessment

Additional testing to further describe the participants included evaluation of hearing and language. See results presented in Table 1.

- **Hearing assessment**

A hearing screen was conducted with all participants to identify any hearing loss. This consisted of a play audiometry assessment, tympanometry, and visual inspection of the ear canal. Any participants who failed this initial screen due to mild hearing loss or non-compliance were reassessed in the University of Canterbury's audiology department clinic by supervised audiology master's students.

Children identified with mild fluctuating hearing loss were not excluded from the study, but treatment for ear infection was sought through the children's general practitioners.

- **Clinical Evaluation of Fundamentals- Preschool (CELF-P)**

The *CELF-P* (Wiig, Secord, & Semel, 1992) was used as a descriptive measure of participants' receptive and expressive language. The assessment is made up of three receptive language subtests and three expressive language subtests. The receptive language subtests evaluate children's understanding of sentence structures, word meanings, and grammar. The expressive component of the test assesses

expressive vocabulary, and word and sentence structure. Normative data for children aged 3 to 6;11 years is provided for individual subtests, combined receptive language score, combined expressive language score, and a total language score. Measures of internal consistency had reliability coefficient ratings ranging from .70 to .92 across the subtests (Wiig et al., 1992). Test-retest reliability of the *CELF-P* is high with reliability coefficients of .60 to .97 and inter-rater reliability averaging 90% agreement for all raters (Wiig et al., 1992). Concurrent validity of the *CELF-P* was evaluated by comparing the *CELF-P* to other measures of language ability. Correlation coefficients ranging from .73 to .90 were reported (Wiig et al., 1992). Correlations between receptive and expressive language scores indicate that related but separate constructs are being evaluated.

There were no inclusion criteria for performance on this assessment. The combined expressive and receptive language scores of participants in the study are provided in Table 1.

Table 1

Performance of participants on measures of speech, language, and hearing ability

	PA1	PA2	PA3	MA4	MA5	MA 6
	(Paul)	(Penny)	(Peter)	(Mark)	(Mike)	(Mary)
Age (months) at start of intervention	55	56	54	55	56	59
Gender	Male	Female	Male	Male	Male	Female
PCC	33	55.5	30.1	41.9	28.6	53
<i>SPELT-P2</i> ^a	65	65	80	65	63	39
<i>PPVT-3</i> ^b	89	95	99	97	120	93
<i>Inconsistency test</i> ^c	28	28	32	32	20	20

Oro-motor assessment ^d	WNL	WNL	WNL	WNL	WNL	WNL
Receptive language score (<i>CELF-P</i>) ^e	85	71	112	91	97	71
Expressive language score (<i>CELF-P</i>) ^e	77	77	102	86	77	65

Notes: PA = phonological awareness intervention with integrated speech targets group; MA = morphosyntax intervention alternating with articulation therapy group; PCC, Percentage of Consonants Correct using PROPH analysis (Long, Fey, & Channell, 1999) of single word items from *Goldman-Fristoe Test of Articulation* and the *Inconsistency Test*, shown as percentage; ^a *SPELT-P2, Structured Photographic Expressive Language Test - Preschool 2*, standard score ($M = 100$; $SD = 15$); ^b *PPVT-3, Peabody Picture Vocabulary Test - Third edition*, standard scores ($M = 100$; $SD = 15$); ^c Inconsistency test from *Diagnostic Evaluation of Articulation and Phonology* (Dodd et al., 2002), shown as percentage of items produced with inconsistent errors (up to 40% considered to be consistent); ^d Oro-motor assessment from *Diagnostic Evaluation of Articulation and Phonology* (Dodd et al., 2002), WNL = within normal limits; Hearing screen, WNL = within normal limits, Mild HL = mild hearing loss; ^e *Clinical Evaluation of Fundamentals- Preschool* (Wiig et al., 1992), standard scores for receptive/expressive language subtests ($M = 100$; $SD = 15$).

2.1.1.3 Current study selection procedure

Participants for the study reported in this thesis were selected from the treatment efficacy group based on a high incidence of consonant clusters errors in the speech assessments. All participants had at least 75% of their cluster production attempts in error in the speech sample analysed. The speech screening assessment incorporated single word productions for picture stimuli from the *Goldman-Fristoe*

Test of Articulation and the *Inconsistency Test*. Only the first of the three productions elicited for the 25 items in the *Inconsistency Test* were analysed for this sample. This sample of 46 items required the participants to attempt 31 consonant clusters (14 in word-initial position, 11 in a medial position, and 3 in word-final position). Table 2 provides a summary of the participants' cluster productions in the initial speech assessment. The participants produced between 0% and 23% of cluster attempts correctly. The error productions varied for each participant, with some deleting a large proportion of the clusters and others reducing most clusters to a single element.

Table 2

Performance of participants on cluster production during combined speech assessment

	PA1	PA2	PA3	MA4	MA5	MA 6
	(Paul)	(Penny)	(Peter)	(Mark)	(Mike)	(Mary)
Accurate production	3	10	10	21	0	23
Cluster substitution	3	37	10	15	3	16
Cluster reduction	34	33	61	21	76	45
Cluster deletion	60	20	19	43	21	16

Note: all scores recorded as a percentage; PA = phonological awareness integrated with speech production intervention; MA = morphosyntax intervention alternating with articulation therapy; Accurate production = cluster produced as adult target (in PROPH analysis); Cluster substitution = two elements produced but with substitution error/s; Cluster reduction = cluster reduced to a singleton phoneme; Cluster deletion = cluster omitted.

2.1.1.4 Assessment probes prior to intervention

- **Cluster Probe Assessment**

Cluster probes were developed for this study to elicit single word productions of a range of cluster forms in word-initial and word-final positions. Pictures and toys were used to elicit test items in a confrontation naming task and informal play activity. There were 42 items with word-initial clusters and 13 with word-final clusters in the probe set. The probe items include examples of a range of cluster types in initial and final positions in words (see Appendix 1 for target word list), including plosive + /r/, fricative + /r/, plosive + /l/, fricative + /l/, /s/ + plosive, /s/ + nasal, and /s/ + /l/ in word-initial position; nasal + /z/, plosive + /s/, nasal + plosive, /s/ + plosive, and plosive + plosive in word-final position. Singleton /s/ word-initial and word-final probes were also administered. There were four target words with both word-initial and word-final clusters (*clapped*, *blocks*, *skunk* and *plant*) and a number of target words with two or more syllables (including *skateboard*, *crocodile*, *grasshopper* and *spiderman*).

- **Individual speech target assessment**

Sets of up to 17 probe words were developed for each speech target selected for intervention. These probes words were primarily common nouns and verbs, and were presented as pictures to elicit productions from the participants. Participants were recorded attempting the probes for each of the phonemes or phonological processes intended to be their targets during intervention. For individual target phonemes these probes included the phoneme in both word-initial and word-final position (e.g., for target phoneme /k/, *car* and *back* were both probe words). Where a phonological process was to be treated in only one position during intervention (e.g., final consonant deletion or cluster reduction), the probe words assessed the target in

that position within a word (e.g., for target process cluster reduction probe words included *stop*, *sleep*, and *spy*, as word-initial /s/ clusters were the targets for intervention).

- **Phonological Awareness Assessment**

Phonological awareness probes previously described by Gillon (2005) were used to assess rhyme awareness and initial phoneme identity. The rhyme awareness task is an oddity task requiring a child to identify the word that does not rhyme out of three spoken words represented by coloured pictures. For example “Which word doesn’t rhyme: tap, lock, sock?” The phoneme matching task requires a child to select the item that starts with the same phoneme as a pictured stimulus item from three spoken and pictured items. For example, Target /f/ for fish: “What starts with /f/: foot, cap, pig?” For each of these tasks, there were two training items and ten assessment items. A letter knowledge task was also used to identify the number of consonant letters the children could identify. This task required a child to identify a named consonant from six written letters presented to them. Vowels were used as distracter items in this task, with four test items per six letters presented. 12 consonants were tested in the task. (See www.cmds.canterbury.ac.nz/people/gillon to download instructions, score sheets and pictures of assessment items for these phonological awareness tasks). The average baseline performance of the participants for these phonological awareness probes is shown in Table 3.

Table 3

Average performance of participants on phonological awareness and letter knowledge probes during baseline assessments

	PA1	PA2	PA3	MA4	MA5	MA 6
	(Paul)	(Penny)	(Peter)	(Mark)	(Mike)	(Mary)
Phoneme identity	50	60	20	25	35	30
Rhyme identity	45	40	35	30	40	20
Phoneme blending	90	30	70	20	50	40
Phoneme segmentation	0	0	0	0	0	0
Letter knowledge	17	96	65	83	25	0

Note: all scores recorded as a percentage

2.1.2 Procedure

2.1.2.1 Assessment

Participants were screened for inclusion in the study and assessed by the author (speech-language therapist) or a senior speech-language therapy student under supervision in a quiet environment in the University campus clinic. Assessments were conducted over a three-month recruitment period during the first term of the pre-school year. Sessions were video- and audio-taped for reliability purposes. All pre-intervention, post-intervention, and follow-up speech assessments were transcribed blind by the author for consistency purposes. A summary of the participants' scores for the pre-intervention assessments is provided in Table 1.

2.1.2.2 Intervention Group Assignment

The six participants were matched into pairs based on their PCC (Percentage Consonants Correct) scores and the percentage of cluster reduction from their speech

samples. They were then randomly assigned to one of the two treatment conditions. Three children received therapy which integrated phonological awareness and speech intervention (Gillon & Moriarty, 2005) and three received therapy which integrated morphosyntactical and articulation intervention (Haskill et al., 2001). The participants have been given pseudonyms to increase ease of recognition when discussed in this thesis. The children who received phonological awareness with integrated speech target intervention are referred to as Paul, Penny and Peter and the children who received the integrated morphosyntax and articulation intervention are referred to as Mark, Mike and Mary.

2.1.2.3 Intervention

Participants attended therapy sessions twice a week in small groups of two to four children. A one hour period was scheduled for each treatment session to ensure that participants received at least 45 minutes of intervention. Intervention was administered in a noise controlled university clinic setting with parental observation facilities attached to the clinics with one-way mirrors. A short break was offered in the middle of each session for children to leave the clinic room for a drink, snack, or toilet break. Therapy was provided in two 6-week blocks with a 6-week break between treatment blocks. Seven children who participated in the larger study (Gillon et al., 2007) were also involved in therapy sessions but not included in this study.

The two treatment conditions were an integrated phonological awareness and speech (PA) intervention and an integrated morphosyntax and articulation (MA) intervention. The PA intervention programme (Gillon and Moriarty, 2006) targeted speech, phonological awareness and letter knowledge, but not expressive language. The MA intervention targeted speech, morphosyntactical awareness and production, but not phonological awareness. Therapy for two groups was provided by the author,

and the other two groups had intervention from supervised senior speech-language therapy students who had received training in the Gillon and Moriarty programme from the programme authors. Any sessions missed during the six week cycles were made up following that cycle of therapy, so that all children received 24 treatment sessions.

2.1.1.1 *Phonological Awareness Intervention*

The first therapy condition was an integrated phonological awareness and speech intervention. The aim of this intervention is to facilitate letter knowledge, early phoneme awareness development, and decrease target speech error patterns. During this intervention each child had at least one phonological process (e.g., word initial /s/ clusters) as a target for the first six weeks and another (e.g., final consonant deletion) for the second six week block of therapy. Phonological awareness exercises were incorporated into speech production activities, including identifying and producing the sounds and names for different letters, word-initial and word-final phoneme identification, and phoneme deletion/addition (Gillon & Moriarty, 2005).

- **Phonological awareness speech targets**

All three participants in this therapy condition had /s/-clusters as their speech targets for the process cluster reduction for the first block of therapy. During intervention for /s/ clusters in cycle 1 of intervention, there was direct teaching of the structure of /s/ clusters within phonological awareness activities (e.g., discussion of the two letters that made up the cluster, discussion of error productions in relation to the need to say both phonemes of the cluster). Target processes for the second cycle of therapy for the participants were: Paul - final consonant deletion; PA - gliding of liquids; Peter - velar fronting. Participants Paul and Penny were in the same therapy group. The other child in their therapy group a participant in the Gillon et al. (2007)

study but was not included in this study. This child had cluster reduction as an intervention target for cycle 1 and velar fronting as an intervention target for cycle 2. Peter was in a group with children targeting cluster reduction and word-initial singleton /v/ for cycle 1. Targets for intervention cycle 2 for this therapy group were palatal fronting, final consonant deletion, and /kr/ clusters. During intervention, the participants were exposed to and expected to attempt other group members' target words and letters.

- **Phonological awareness sessions**

Each phonological awareness sessions included activities that targeted the following areas:

1. Phoneme awareness and identity

- a. Matching items or target words to others that start or end with the same phoneme. For example, *Phoneme categorisation*.

Therapist: This is my dog *Spot*. *Spot's* name has the /s/ sound at the beginning. Let's something for *Spot* to eat that has a /s/ at the beginning too. Which one starts with /s/...popcorn, spaghetti, or muffin?
Listen for the /s/ sound at the start.

- b. Deciding which phoneme a word a word starts or ends with from the selection provided by therapist. (See Appendix 2 and Gillon and Moriarty (2005) for further examples of activities used in the phonological awareness intervention programme).
- c. Finding an item that starts or ends with a phoneme provided.
- d. Identifying the phoneme at the start or end of a word.

2. Letter name / sound knowledge

- a. Learning the name of a letter.

- b. Learning the sound a letter makes.
- c. Choosing a letter from two or more choices when given the name or sound it makes.
- d. Providing the name or sound of a letter when requested.

3. Speech target practice

- a. Introduction of target sound
- b. Practice of target sound in the phoneme awareness activities

Activities that integrated the above were used to relate the targets of intervention to each another. Many activities during the sessions had more than two or more of the above target areas. For example, *Writing on the whiteboard*.

Therapist: I have written a word on the whiteboard. The word is *stop*. Who can see what letter is at the start of *stop*? (Child A: “s”) What sound does the letter “s” make Peter? (Child B: /s/) That’s right “s” makes the /s/ sound. We have been practicing the /s/ sound haven’t we? Let’s all make a /s/ sound for the letter “s”. (Child A, B and C: /s/) Let’s all have a turn at saying *stop*. (Child A, B and C: *stop*) I heard /s/ sounds at the start of your words. Now, Peter, it’s your turn to have a go at writing. Come and point to the letter “s” for me.

Great! Now rub the letter “s” off the board for me. Now we’ve made a new word without the /s/. The new word is *top*. What happens if we put the “s” in front of the word *top* again? That’s right, we get *stop*. Write the letter “s” at the start of the word to make it say *stop*.

The example activity above incorporated letter name identification, letter sound identification, target phoneme and word production practice, phoneme manipulation, and letter writing into one therapy task.

2.1.1.2 *Morphosyntax and Articulation Intervention*

The second therapy condition was a morphosyntax intervention alternating with articulation therapy. This intervention alternated weeks of treatment for morphology and phonology targets in a cyclic type of approach (Haskill, 2001). Two sessions targeting a morphological structure are followed by two sessions of speech intervention the next week. All articulation therapy targets were singleton phonemes for this programme. No consonant clusters were targeted during the speech sessions.

Morphosyntax targets

The three morphological structures that were targeted during intervention were: the regular third person singular form of verbs (e.g., blows, makes, eats); the regular past tense of verbs (e.g., looked, washed, talked); and the copular form of the verb ‘to be’ (e.g., I am tired, They are mine, It is empty). Each morphological structure was targeted for four intervention sessions in total, two during each cycle of therapy.

• Morphosyntax sessions

The morphosyntax sessions followed a regular pattern, which included:

1. Auditory bombardment - A picture book was used to begin each session with the session’s target structure being stressed within the body of the text and discussion around the story.
2. Focused stimulation activity - Models of the target structure were provided during a group activity (e.g., making bubble mixture, making cat masks).
3. Elicited production activity - At least 10 attempts at the target structure were elicited from each child in the group during a discussion of the focussed stimulation activity and / or using the items made during the activity.

4. Song - A song with repeated use of the morphological structure was used to close each session.

The therapist provided models and encouraged the group members to attempt a range of words that used the target morpheme within the session, but no specific vocabulary list was prescribed for these sessions. For this reason, the percentage of target morphemes with word-final clusters has not been included.

- **Speech Targets**

Each of the group members had different target singleton phonemes treated during the speech sessions. No consonant clusters were treated as speech targets for the participants in the articulation sessions of this programme. Mark had velar fronting as a speech target for their speech sessions. Mary presented with stopping of fricatives, and /s/-initial words were selected as speech targets. The other child in the therapy group with Mark and Mary /f/-initial words selected as speech targets. Mike was in the other morphosyntax intervention group, with final consonant deletion as their target process. The two other children in this group presented with palatal fronting, deaffrication, and stopping of later fricatives. Their speech targets were /k, tʃ, ʃ, v, z/. All children were expected to attempt each other's target words occasionally during the intervention sessions, but guidance regarding accurate production beyond provision of a clear model, was reserved for their target sounds.

- **Speech Sessions**

Speech intervention was provided using traditional methods, with sounds being introduced in isolation first, then CV (consonant-vowel) combinations, CVC (consonant-vowel-consonant) words, and gradually introducing more complex

situations in which to produce the target sounds. Speech therapy sessions followed the same general pattern as the morphosyntax sessions, which included:

1. Auditory bombardment - A picture book was used at the beginning of the session with words with the session's target sounds used in word-initial position within the body of the text and discussion around the story.
2. Introduction of target sounds - Each child's target sound was introduced with articulation placement instruction provided when required.
3. Elicited production activities - Activities were set up to provide maximum opportunities for speech target production practice (e.g., fishing for pictured target words). Modelling and cuing were provided by therapist to elicit accurate productions when necessary.
4. Song - A song with repeated use of the speech targets was used to close each session.

2.1.2 Control for activity and speech stimulus items

The two types of intervention approaches were similar in that they both used play activities to stimulate development and actively engaged children in physical activities. Other similarities between the two types of intervention included:

1. Both programmes provided therapy for the same frequency, length and number of sessions.
2. Parents, siblings, and/or caregivers observed both types of intervention from observation rooms behind one-way mirrors in both types of intervention.

The participants were aware that their family members were observing from the adjoining observation rooms.

3. There was no specific home practice provided for either intervention programme, however parents were not discouraged from practicing target sounds or activities at home.
4. The stimulus picture cards for target words were in a similar format for both groups: that is a colourful picture of the target word with the target word typed in large clear print (font size 40) beneath the stimulus picture.
5. A similar number of target words were introduced for each speech target for both types of intervention.

Treatment fidelity was ensured through review of more than 10% of the treatment sessions. This was done using checklists devised for each programme (see Appendix C). The PA sessions with integrated /s/ cluster targets were reviewed to ensure that all sessions included phoneme awareness and manipulation activities, /s/ cluster production practice, letter name and letter sound activities. The MA sessions were reviewed to ensure that morphosyntax targets and articulation targets were alternated weekly. Morphosyntax sessions were checked to ensure that all sessions included an auditory bombardment activity, a focussed stimulation activity, and an elicited morpheme production activity. Articulation therapy sessions were checked to ensure that all sessions included an auditory bombardment activity, speech target introduction, and an elicited speech production activity. Treatment fidelity for all MA and PA intervention sessions was 100%.

2.1.3 Reassessment

A number of assessments were used as probes to measure change in speech (particularly cluster production), expressive morpheme use, and phonological awareness due to the intervention.

2.1.3.1 *Cluster production*

Cluster production was assessed in this study using multiple single-subject design. The cluster probes described previously were administered pre-intervention, immediately post-intervention and at follow-up 3-months post-intervention. These speech productions were compared for each child to measure the impact of the two intervention programmes on the production of consonant clusters in word-initial and word-final positions. Pre-intervention cluster probe data was recorded from 2nd – 16th May (prior to week 1). Cluster probe data for immediately post-intervention was recorded from 7th – 25th September (following six weeks of intervention). Cluster probe data for follow-up was recorded from 5th – 18th December (following the second six weeks of intervention). Each child produced between 27 and 37 different words with initial clusters and between 10 and 13 different words with final clusters in all three samples of the cluster probes.

The cluster probes were digitally recorded with a SONY ECM-MS907 stereo condenser microphone held or placed within 16 inches of the child's mouth. Spontaneous or prompted productions were elicited where possible, otherwise a model was provided, with delayed or direct imitation productions encouraged. Where there was more than one attempt at a word during the assessment, the first spontaneous attempt was selected as the target cluster attempt to score. Where all attempts at a target word were either direct or delayed imitation, the first attempt was scored.

2.1.3.2 *Speech production*

The effect of the intervention programmes on the participants' speech production was measured by comparing pre-intervention, immediately post-intervention, and follow-up 3-months post-intervention speech samples. The

productions of single word items elicited using the Goldman-Fristoe Test of Articulation (Goldman & Fristoe, 1972) and Inconsistency Test (Dodd et al., 2002) were compared. The speech probes that were specific to each child's individual speech target/s (described previously) were also compared to describe change in production of the phonemes targeted during intervention. These were administered pre-intervention, following therapy cycle 1, following the 6-week therapy break, and following therapy cycle 2. All speech assessments were audio- and video-recorded for reliability purposes.

2.1.3.3 *Expressive Morpheme Use*

Scores were compared for pre- and post-intervention administrations of the Structured Photographic Expressive Language Test - 2 (Dawson et al., 2004) to measure change in the use of expressive morphemes. The expressive morpheme assessments were scored on-line by the therapist administering the assessment.

2.1.3.4 *Phonological Awareness*

A range of phonological awareness probes (described previously) were administered pre- and post-intervention to measure change in the understanding of phonological concepts. The phonological awareness probes were scored on-line by the therapist or student-therapist administering the assessment.

2.2 Data Transcription and Analysis

All speech samples with target words from the Goldman-Fristoe Test of Articulation, Inconsistency Test, and cluster probe data were transcribed off-line by the author from audio or digital video recordings. A sample of 10% of the cluster probe data and 10% of the speech assessment data were randomly selected and transcribed by

experienced transcribers to measure reliability. Point-to-point reliability was calculated for the cluster probe data based on each judge's transcription of each consonant in the cluster. Segmental transcriptions that were identical (excluding diacritics) were coded as agreements. There was 93.1% agreement for segmental transcriptions between the two judges' transcriptions for the cluster probe sample. Point-to-point reliability was also calculated for the speech assessment data based on each judge's transcription of each consonant in the samples. Agreement was calculated as above, with 84% agreement for phonemes in the speech samples. This is agreement is lower than for the cluster probes, primarily due to lower quality recordings for the speech samples.

Speech Sample Analysis

The speech samples gathered using target words from the Goldman-Fristoe Test of Articulation (Goldman & Fristoe, 1972) and the first attempts for the Inconsistency Test (Dodd et al., 2002), were analysed using Computerised Profiling software (Long et al., 1999) to determine the percentage consonants correct (PCC).

Individual Speech Target Probes

Productions for each child's individual speech target probes were scored as correct if the target phoneme was pronounced as the adult target. The glottal stop [ʔ] was scored as correct for word-final /t/ attempts as this is commonly seen in the productions of adults in connected speech. Percentage of productions correct for direct imitation and spontaneous productions were calculated for each assessment of target probes. These were scored online by the therapists and the tape recordings listened to following assessment to ensure accurate transcriptions. Where there was difficulty transcribing the probes, agreement was reached through consensus following group review of the recordings.

Cluster production analysis

The cluster production attempts were scored as either correct or incorrect to gain accuracy measures that could be compared across the three probe trails. A consonant cluster production attempt was considered to be correct if the production matched the adult target form. However, following Kirk and Demuth (2005) some mismatches between the adult target form of the cluster and the children's productions were ignored. These mismatches included cluster attempts with voicing discrepancies, the insertion of the schwa vowel between the first and second element, and predictable substitutions of one or more cluster elements with phonemes in error when produced as singletons. See Table 4 for examples of mismatches that were scored as correct cluster productions. Error productions included clusters with unpredictable substitutions, metathesis, non-schwa epenthesis, cluster reduction, and cluster deletion. See Table 4 for examples of error productions.

Table 4

Examples of cluster production attempts classified as correct and error productions

Correct productions	Target word	Child's response
Adult form	star /sta/	[sta]
Voicing discrepancies	beans /binz/	[bins]
Schwa epenthesis	block /bl□k/	[bəl□k]
Predictable substitution/s	crab /kræb/	[træb]
		(where child presents with velar fronting with singletons)
Error productions		
Unpredictable	fly /fla□/	[gla□]

substitution/s		(where the child does not present the /f/ substituted with /g/ as a singleton)
Metathesis	desk /d□sk/	[d□ks]
Non-schwa epenthesis	tree /tri/	[t□ri]
Reduction	smoke /smo□k/	[mo□k]
Deletion	paint /pe□nt/	[pe□]

Chapter 3

Results

The hypotheses considered the impact of the two types of intervention on the cluster production of participants with speech sound disorder. Speech production data was analysed and compared in order to identify if these hypotheses correctly predicted post-intervention performance. Items from the cluster probes, individual speech target probes and speech assessments which included the participants' target phonemes and/or consonant clusters were included in the analysis where appropriate. The data has been analysed using the two standard deviation method to determine whether the improvements in production accuracy were significant. Variability of production pre-intervention was assessed by determining the mean and standard deviation for the baseline assessments (Portney & Watkins, 2000 p. 256). If follow-up productions were more than two standard deviations above the mean of the baseline measures, then the improvement was considered to be significant.

3.1 Effect of treating /s/ clusters in phonological awareness intervention

Hypothesis 1: That phonological awareness intervention that integrates the speech production goal of word-initial /s/ clusters will:

- a) Improve the production of target /s/ clusters;*
- b) Result in a transfer of skill production to /s/ clusters that are not targeted in therapy; and*
- c) Result in improved production of singleton fricatives.*

The first hypothesis addressed the effect of phonological awareness intervention on the participants' production of /s/ clusters. The phonological awareness intervention integrated the speech production goal of word-initial /s/ clusters.

To test the first hypothesis the accuracy of production of both target and non-target /s/ clusters for each of the participants who received speech production intervention for the clusters /st, sp, sl/ during the first phase of the phonological awareness intervention was analysed. Standardised speech assessments and the cluster probes were administered during baseline (pre-intervention), post-intervention, and at follow-up (3-months post-intervention). Probes for the /s/ cluster speech targets were administered to the children receiving phonological awareness intervention pre-intervention, immediately following intervention cycle 1, prior to intervention cycle 2, and post-intervention. Various comparisons were undertaken for each child pre -, during and post-intervention. This involved:

1. comparison of the production of the target /s/ cluster/s with non-target /s/ clusters

2. comparison of the production of target /s/ cluster/s with untreated consonant + liquid word-initial clusters
3. comparison of the production of target /s/ cluster/s with untreated singleton fricatives
4. comparison of the progress of the three children whose intervention included /s/ cluster production practice (as part of the phonological awareness intervention) to the three children who received the language intervention and speech production practice for singleton phonemes

The mean and standard deviations for the speech targets and generalisation targets were calculated for each child from the baseline measures. The production accuracy at follow-up was compared to these scores to determine if improvements were significant. These results are presented in Table 5.

Table 5 Participants' average production accuracy scores (percent correct) for Hypothesis 1 data pre-intervention and at follow-up 3 months post-intervention.

PA Group	Pre-Intervention	Follow-up
	M (SD)	
<i>Paul</i>		
Target /s/ clusters	0 (0)	22*
Non-target /s/ clusters	0 (0)	27*
Singleton fricatives	26.7 (3.1)	49*
Consonant + liquid clusters	2.3 (4)	24*
<i>Penny</i>		
Target /sl/ cluster	0 (0)	100*
Target /st, sp/ clusters	80.7 (5.5)	100*

Non-target /s/ clusters	100 (0)	90
Singleton fricatives	58.0 (6)	83*
Consonant + liquid clusters	3 (5.2)	83*
<i>Peter</i>		
Target /s/ clusters	0 (0)	38*
Non-target /s/ clusters	0 (0)	64*
Singleton fricatives	3 (3)	56*
Consonant + liquid clusters	7.3 (6.4)	24*
<hr/> MA Group <hr/>		
<i>Mark</i>		
/s/ clusters	0 (0)	15*
<i>Mike</i>		
/s/ clusters	0 (0)	0
<i>Mary</i>		
/s/ clusters	0 (0)	8*

Pre-intervention are the average percentage correct scores (M = mean; SD = standard deviation) from three assessment probes administered in the week prior to intervention. Follow-up scores are from one assessment probe administered 3 months post-intervention.

* = Significant change (above expected range of improvement using a Two- Standard deviation band method).

Participant : Paul

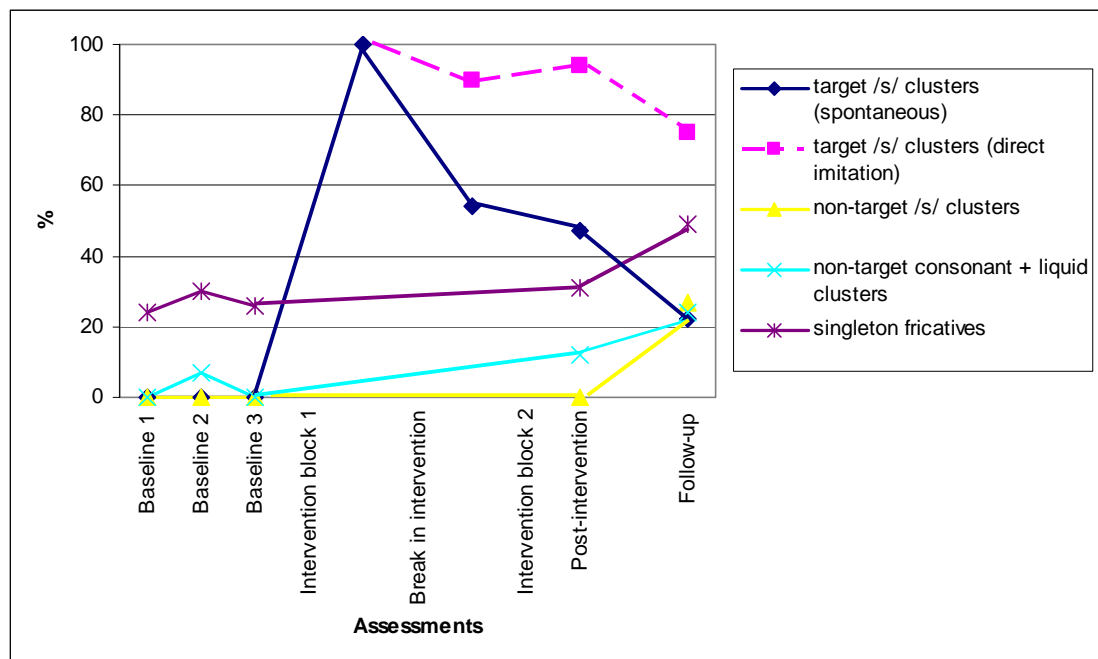
Word initial /s/ clusters

Paul produced all target /s/ clusters incorrectly in both spontaneous and imitated production attempts during the baseline measures. He reduced all word-

initial /s/ clusters to a singleton consonant by deleting the /s/ from the cluster, and retaining the second cluster element. This follows the common reduction pattern for /s/ clusters for children with typical development (Smit, 1993).

Improvement to 100% (17/17) accuracy on the /s/ cluster speech probes was seen immediately following intervention block 1 during which the /s/ clusters /st, sp, sl/ were speech targets and integrated into the phonological awareness activities. Spontaneous productions of these target /s/ clusters were less accurate when reassessed after the 6 week break between therapy blocks (54% (7/13) correct). The 46% of spontaneous /s/ clusters that were produced incorrectly were once again realised as reductions with the second cluster element retained. Accuracy was much higher (90% (9/10) correct) when the /s/ cluster probes were re-evaluated with Paul imitating the therapist's model. See Figure 1 for a summary of these findings.

When reassessed post-intervention the spontaneous productions of the target /s/ clusters remained stable. This assessment followed a second block of therapy, during which word-final singleton consonants /p, t, n/ were speech targets. Paul continued to produce the target /s/ clusters with greater accuracy when imitating the therapist's model. Error productions continued to be reductions to the second cluster element with the /s/ deleted. This trend continued in the follow-up assessment, 3 months post-intervention, and his productions were again less accurate for spontaneous target /s/ clusters than for productions with direct imitation. Improvements made in both spontaneous and imitated productions were significant. Figure 1. The percentage of accurate productions of word initial target and non-target /s/ clusters, non-target fricative + liquid clusters, and /s/ singletons by Paul.



Generalisation

There was some improvement in Paul's production of non-target /s/ clusters (e.g., /sm, sn, sk/). There was an increase in accuracy from 0% at baseline and post-intervention to 27% (3/11) accurate for the follow-up assessment. This improvement was significant. All correct productions at this time were in direct imitation, with spontaneous productions resulting in reduction of the target cluster. This suggests that although production of target /s/ clusters improved, generalisation to non-target /s/ clusters did not occur to the same extent.

Consonant + liquid clusters (e.g., /gr, fl/) were used as a control measure as they were not targeted during intervention. There was some improvement in production accuracy of these control clusters over the course of the study. At baseline, he was accurate for 2% (7/39) attempts at these clusters, post-intervention he was 8% (3/37) accurate, and at follow-up he was 24% (8/34) accurate. This improvement was significant, but was more gradual than the changes seen in target /s/ clusters.

Paul's production of singleton fricatives showed some improvement over the course of the intervention. There was significantly improved accuracy when

reassessed at follow-up. This was the result of improved accuracy for word-final fricatives. At baseline and during the post-intervention assessment all word-final singleton fricatives were omitted. During the follow-up assessment, only word-final /z/ was omitted, with accurate production (e.g., for the fricatives /s, v, f/) or fricative substitution for other fricatives in word-final position (e.g., target /f/ produced as /s/, and /θ/ produced as /f/). The percentage of accurate word-initial fricatives changed little over the course of the study. However there was evidence of movement towards accurate production of singleton fricatives. During the baseline measures, 66% (4/6) of the error productions for fricatives were produced as plosives, and during the post-intervention and follow-up assessments, there was no evidence of use of the stopping process in error productions for singleton fricatives. The data for Paul that has been described above is summarised in Figure 1.

Participant : Penny

Speech targets

Penny produced all target /sl/ clusters incorrectly in both spontaneous and imitated production attempts during the baseline measures. Most of her incorrect attempts at these clusters were reduced to the singleton /s/ phoneme. The cluster /sl/ is grouped with consonant + /l, w, r/ clusters, rather than other /s/ clusters when describing typical reduction patterns. Reducing to the first element and deleting the /l/ is a typical reduction error for this type of cluster (Smit, 1993). Penny also realised the /sl/ cluster with substitution errors as the cluster [sj] and as the singleton fricative /ʃ/ during the baseline assessments. The cluster [sj] reflected one of her substitution realisations of the singleton /l/ (she substituted /l/ for either [w] or [j] as a singleton).

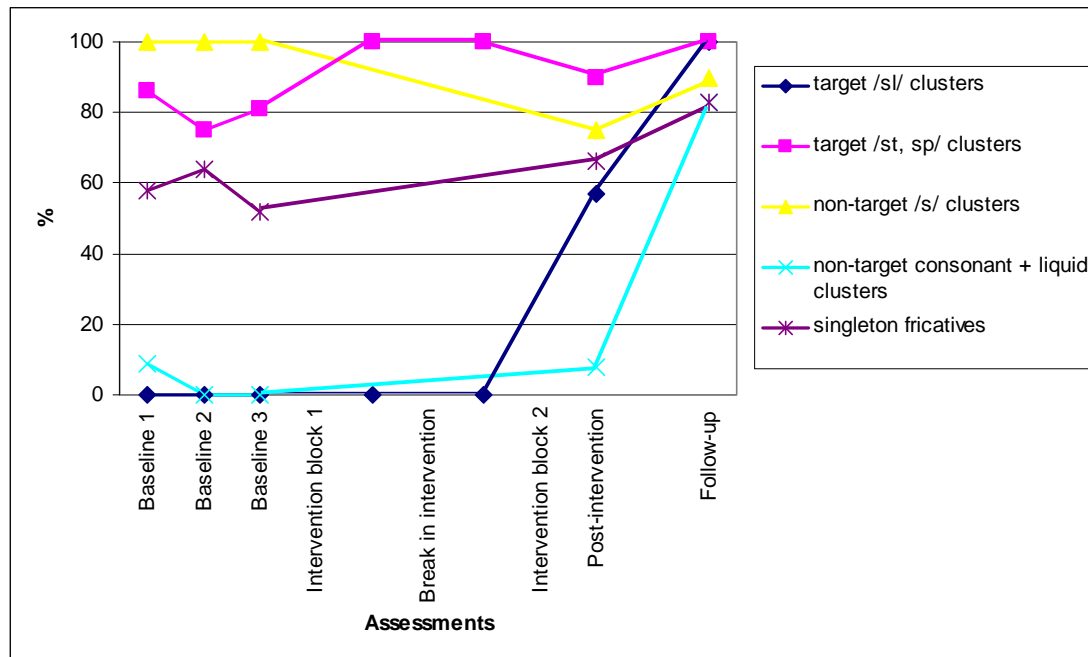
Penny was 75% (9/12) accurate for productions of /st/ clusters and 86% (6/7) accurate for her productions /sp/ clusters prior during the baseline measures. Her accuracy with these clusters remained high throughout the study. If involved in individual therapy, these may not have been selected as targets for intervention as they appeared to be developing without treatment. Due to the group setting for intervention the targets for other children were taken into consideration when deciding on appropriate speech targets for intervention. As other children in the intervention group had these clusters as targets, Penny was also exposed to speech production and phonological awareness intervention activities where /st/ and /sp/ were the targets.

The clusters /st, sp, sl/ were integrated as speech production targets during the first block of phonological awareness intervention. When assessed immediately following intervention block 1 and after the 6-week break prior to intervention block 2, Penny's production of the target /st/ and /sp/ clusters had improved to 100% accuracy. Her production of her target /sl/ clusters was still inaccurate, with continued realisation of these clusters as [sj], [s] and [□].

During intervention block 2, three group members each had different speech production targets. Penny had the liquid singleton phonemes /l/ and /r/ as her targets, as she produced these liquid phonemes as glides both as singletons and in the context of clusters during the initial assessments. When reassessed following the second block of therapy, her spontaneous productions of the target /sl/ had improved to 57% (4/7) accurate. The /l/ singleton was produced with 100% accuracy when reassessed at this time. During the follow-up assessment 3-months post-intervention, Penny produced all target /s/ clusters, including /sl/ clusters, with 100% accuracy. The improvements

in production for all three /s/ clusters targeted in treatment were significant. These results are summarised in Figure 2.

Figure 2. The percentage of accurate productions of word initial target and non-target /s/ clusters, non-target fricative + liquid clusters, and /s/ singletons by Penny.



Note: The target /sl/ clusters are presented separately to the other target /s/ clusters due to this participant's particular difficulty with this cluster when compared to her productions of /st/ and /sp/.

Generalisation

Penny's production of non-target /s/ clusters (e.g., /sm, sn, sk/) remained high, with accuracy between 75% (6/8) and 100% (7/7) throughout the study. As Penny's productions of these non-target /s/ clusters were 100% (7/7) during the baseline measures, they were not useful to indicate any generalisation from the target /s/ clusters.

Consonant + liquid clusters (e.g., /gl, fr/) were used as a control measure as they were not targeted during intervention. Penny's accuracy was 3% during the baseline measures for these clusters. These clusters were generally realised as clusters

with substitution errors, with the liquid phoneme of the cluster produced as /w/ (e.g., /fr/ and /fl/ produced as [fw]). Although these errors were predictable from her productions of the singleton liquids, they were treated as errors in order to identify improvements secondary to intervention (the liquid phonemes /r/ and /l/ were speech targets for the second block of intervention. There was little change in production accuracy of these control clusters when reassessed post-intervention (8% (3/34). However, at the 3-month follow up there was significant improvement to 83% (29/35), due to accurate production of the liquid elements in these clusters.

Penny's production of singleton fricatives showed little improvement over the course of the intervention. There was however a significant increase in accuracy when reassessed at follow-up three months post-intervention. This was primarily due to her improved production of word-final fricatives. These fricative singletons were occasionally realised as plosives during the baseline measures, occasionally deleted, and /ɱ/ was produced as /s/ due to the depalatisation process. During the follow-up assessment, a higher percentage of the fricatives were produced accurately, there were no examples of final fricative deletion, and less stopping and depalatisation in her error productions. In comparison, there was little change in word-initial fricative accuracy over the course of the study. The data for Penny that has been described above is summarised in figure 2.

Participant: Peter

Speech targets

Peter produced all target /s/ clusters incorrectly in both spontaneous and imitated production attempts during the baseline measures. He reduced all word-initial /sp/ and /st/ clusters to the second element by deleting the /s/ from the cluster. As reported previously, the deletion of the /s/ phoneme is the most common reduction

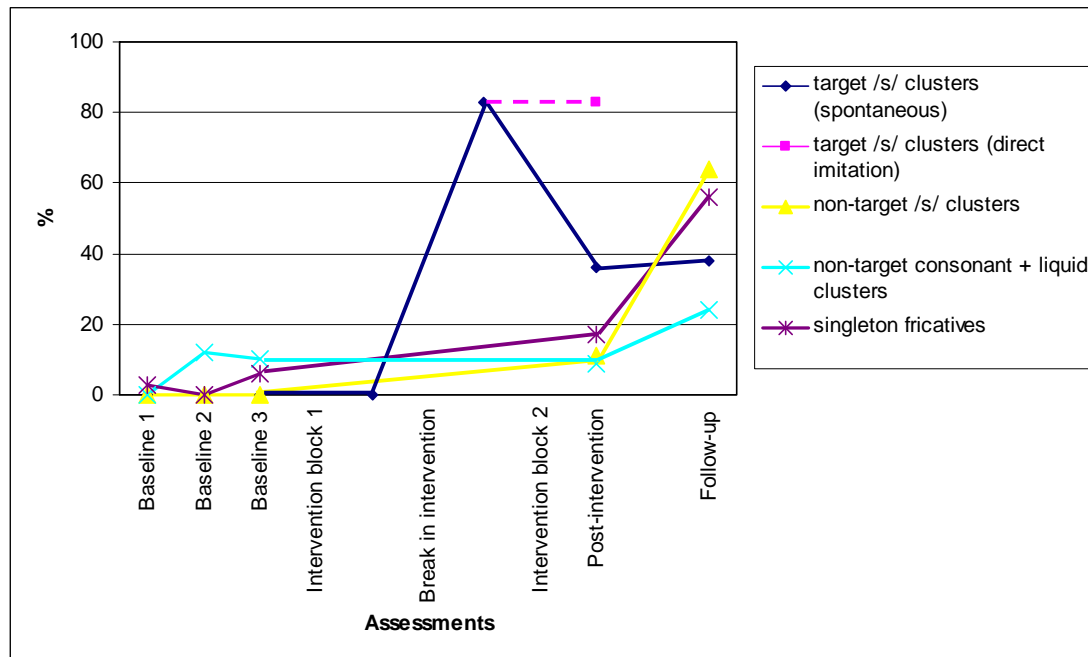
pattern for /s/ + consonant clusters (Smit, 1993). The target /sl/ clusters were produced as [gl] and [gj] during the baseline measures.

During intervention block 1, the /s/ clusters /st, sp, sl/ were speech targets and integrated into the phonological awareness activities. There was no increase in spontaneous production accuracy of the target /s/ clusters when reassessed immediately following intervention block 1. There had been evidence of improved production seen during the intervention sessions, but this was not evident in the spontaneous production attempts during this assessment. Unfortunately the therapist did not repeat the probe assessment providing a direct model after eliciting only inaccurate productions during assessment. This may have shown improved productions of the target /s/ clusters. When reassessed after the six-week break in intervention, Peter produced the target /s/ clusters with 83% accuracy. This suggests that this participant required time to internalise the productions of the target clusters following intervention.

During the second block of intervention, Peter had /k/ as a speech production target. When reassessed following the second intervention block, both spontaneous productions and direct imitation productions were elicited to evaluate Peter's productions. Spontaneous productions of these target /s/ clusters were less accurate at this time (36% (9/25) accurate) however his productions when imitating the therapist's model remained reasonably accurate (83% (15/18)). Peter's spontaneous productions of the target /s/ clusters stayed reasonably stable from the post-intervention assessment to the follow-up assessment, 3 months post-intervention. The types of errors he made when attempting to produce /s/ clusters throughout the study were similar to those described for the baseline measures. His productions at this time

were significantly more accurate than during baseline. These results are summarised in Figure 3.

Figure 3. The percentage of accurate productions of word initial target and non-target /s/ clusters, non-target fricative + liquid clusters, and /s/ singletons by Peter.



Generalisation

There was little improvement in Peter's production of non-target /s/ clusters (e.g., /sm, sn, sk/) during the intervention phase of the study. However, there was a significant increase in accuracy of these clusters during the follow-up assessment. This increase was due to 100% (5/5) accuracy with /s/ + nasal clusters during this measure. This may indicate that given time, generalisation did occur with /s/ clusters that were not targets of intervention.

Consonant + liquid clusters (e.g., /gr, fl/) were used as a control measure as they were not targeted during intervention. At baseline and post-intervention, Peter was 9% (3/32) accurate with consonant + liquid clusters. When reassessed at follow-up, he produced 24% (8/34) of these untreated clusters correctly, which was a significant improvement.

Peter's production of singleton fricatives showed little improvement over the course of the intervention from 3% (1/25) accurate at baseline to 16% (4/25) post-intervention. There was a significant increase in accuracy when reassessed at follow-up, with singleton fricatives being produced with 56% (14/25) accuracy. This significant improvement was the result of improved production of both word-initial and word-final fricatives. Word-final fricatives were generally omitted during the baseline measures. They were more accurately produced, with the error attempts generally realised as substitute fricatives or plosives during the post-intervention assessment. At follow-up 54% (7/13) of word-final fricatives were produced accurately, with the error productions being primarily fricative substitutions (e.g., /θ/ produced as [f]). Peter showed improvement towards accuracy with word-initial fricatives over the course of the study. In the baseline and post-intervention measures, word-initial fricative attempts were produced as [d] due to the stopping process 60% (6/10) and 72% (8/11) of the time. During the follow-up assessment, this had reduced to 38% (5/13) occurrence, with the same number of the word-initial fricatives being produced correctly. The data for Peter that has been described above is summarised in figure 3.

Summary of cluster change for children in PA intervention

All three children whose intervention included /s/ cluster production practice as part of the phonological awareness intervention showed significant improvement in their production of the target /s/ clusters during the study:

1. Paul showed some improvement from 0% at baseline to 23% accuracy at follow-up for his spontaneous attempts at the target /s/ clusters. He was also able to achieve a higher level of accuracy (75% accurate) for the target clusters with a direct model.

2. Penny had maintained her increased accuracy with the /st/ and /sp/ targets, and had achieved 100% accuracy with /sl/ by the follow-up assessment.
3. Peter had improved from 0% accuracy to sustaining more than 35% accuracy for the target /s/ clusters during the post-intervention and follow-up assessments.

Comparison to alternative intervention

The /s/ cluster productions of the children who received the phonological awareness intervention (PA) were compared with productions for the children who received the morphosyntax intervention alternating with articulation therapy for singleton phonemes (MA). Two of these children had significant improvements in production, but much less than the PA children. The other child's productions of /s/ clusters did not improve.

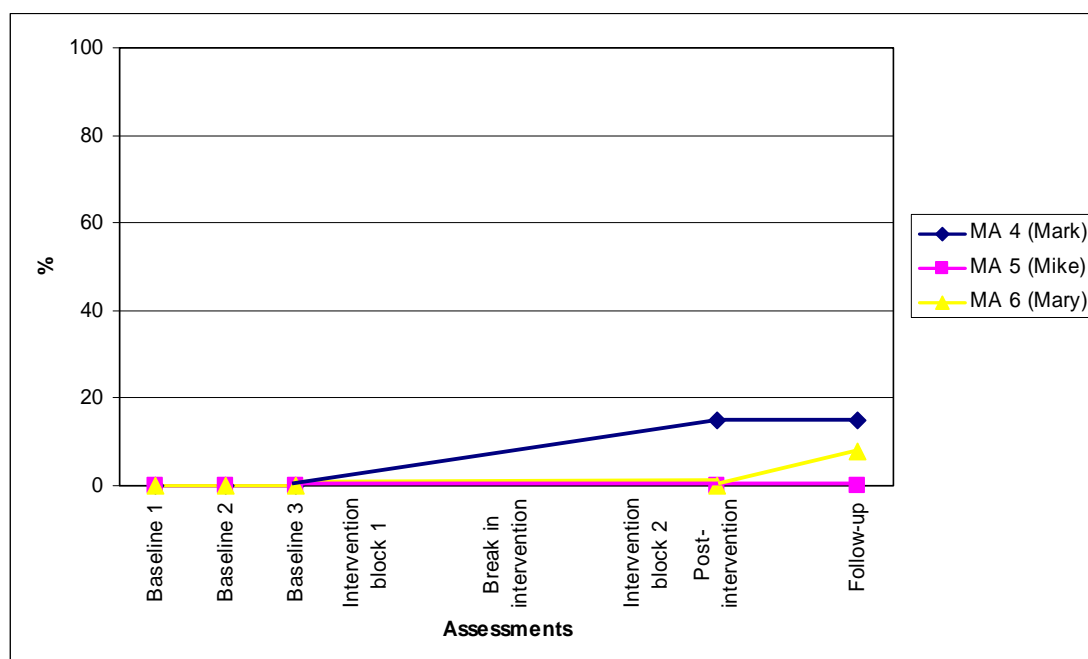
Mark improved from 0% (0/13) to 15% (2/13) accuracy productions (both /sl/) correct during the post-intervention assessment. This was maintained during the follow-up assessment with one /sp/ and one /sl/ cluster in word-initial position produced correctly. Throughout the study, he reduced /sp, st, sl/ clusters to the second element of the cluster by deleting the /s/ phoneme.

Mike had 0% accuracy for /st, sp, sl/ clusters throughout the study. All attempts at these clusters were reduced to singleton phonemes. /st/ and /sp/ reduced to [t] and [p] through deletion of the /s/ phoneme and /sl/ reduced to [s] or the substitution phoneme [ʃ]. Both of these reduction patterns are those most commonly seen in children with typical development as previously discussed (Smit, 1993).

Mary presented with 0% accuracy during the baseline measures and post-intervention assessment. She produced one word with word-initial /sp/ cluster

accurately during the follow-up assessment. Most attempts at /s/ clusters were reduced throughout the study, with reduction patterns similar to those described for Mike. See Figure 4 for a summary of the results for /sp, st, sl/ cluster production for these control children who did not receive intervention for /s/ clusters.

Figure 4. The percentage of accurate productions of word-initial /sp, st, sl/ clusters for participants Mark, Mike and Mary, who received the language intervention and speech production practice for singleton phonemes.



This comparison suggests that the improvements in the production of the target /s/ clusters made by the participant whose intervention included /s/ cluster production practice as part of the phonological awareness intervention are not likely to be due to maturation, as none of the children who received the language intervention and speech production practice for singleton phonemes showed the same level of improvement in production of these target /s/ clusters over the same period of time.

Summary

The first hypothesis considered the effect of treating /s/ clusters in the PA intervention on word-initial consonant cluster production. It was predicted that this intervention would result in improved production of the target /s/ clusters, untreated /s/ clusters, and untreated singleton fricatives. This hypothesis was supported by the data as significant improvements were made by all children. Significant improvement was seen in productions of both targeted and untreated /s/ clusters and untreated singletons for the participants who received therapy targeting /s/ clusters in the PA intervention. The children who received the MA intervention with no therapy for word-initial /s/ clusters had less improvement in their productions of /s/ clusters.

3.2 Effect on word-final cluster production of treating word-final morphemes in language intervention

Hypothesis 2: That language intervention that increases the awareness of word-final morphemes will improve the production of word-final clusters.

The second hypothesis addressed the effect of language intervention that increased awareness and use of word-final morphological structures on participants' production of word-final clusters. It was predicted that targeting word-final morphemes would improve the participants' production of word-final clusters as many word-final clusters are created when adding these morphemes to the end of words (e.g., /pt/ in *clapped*, /ks/ in *likes*), and increasing the use of these morphemes will increase the attempts at producing word-final clusters.

To address this hypothesis the accuracy of production of word-final clusters for each of the participants who received language intervention targeting word-final morphemes has been analysed.

Comparisons were undertaken for each child at baseline, post-intervention and at follow-up in the following areas:

1. comparison of the production of the word-final clusters with word-initial clusters
2. comparison of the production of the word-final clusters for the three children whose intervention included word-final morphemes (as part of the combined language and speech intervention) to the three children who received the phonological awareness intervention with integrated speech production practice for word-initial /s/ clusters and singleton phonemes.

The mean and standard deviations for the speech targets (word-final clusters) and control word-initial clusters were calculated for each child from the baseline measures. The production accuracy at follow-up was compared to these scores to determine if improvements were significant. These results are presented in Table 6.

Table 6. Participants' average production accuracy scores (percent correct) for Hypothesis 2 data pre-intervention and at follow-up 3 months post-intervention.

MA Group	Pre-Intervention	Follow-up
	M (SD)	
<i>Mark</i>		
Target word-final clusters	2 (3.5)	0
Non-target word-initial clusters	28 (4.5)	42*
<i>Mike</i>		
Target word-final clusters	0 (0)	24*
Non-target word-initial clusters	0 (0)	2*
<i>Mary</i>		

Target word-final clusters	31 (6.9)	47*
Non-target word-initial clusters	0 (0)	30*
Control Group		
<i>Paul</i>		
Word-final clusters	0 (0)	6*
<i>Penny</i>		
Word-final clusters	28 (1.7)	82*
<i>Peter</i>		
Word-final clusters	4.7 (4.2)	94*

Pre-intervention are the average percentage correct scores (M = mean; SD = standard deviation) from three assessment probes administered immediately pre-intervention. Follow-up scores are from one assessment probe administered 3 months post-intervention.* = Significant change (above expected range of improvement using a two-standard deviation band method).

Participant : Mark

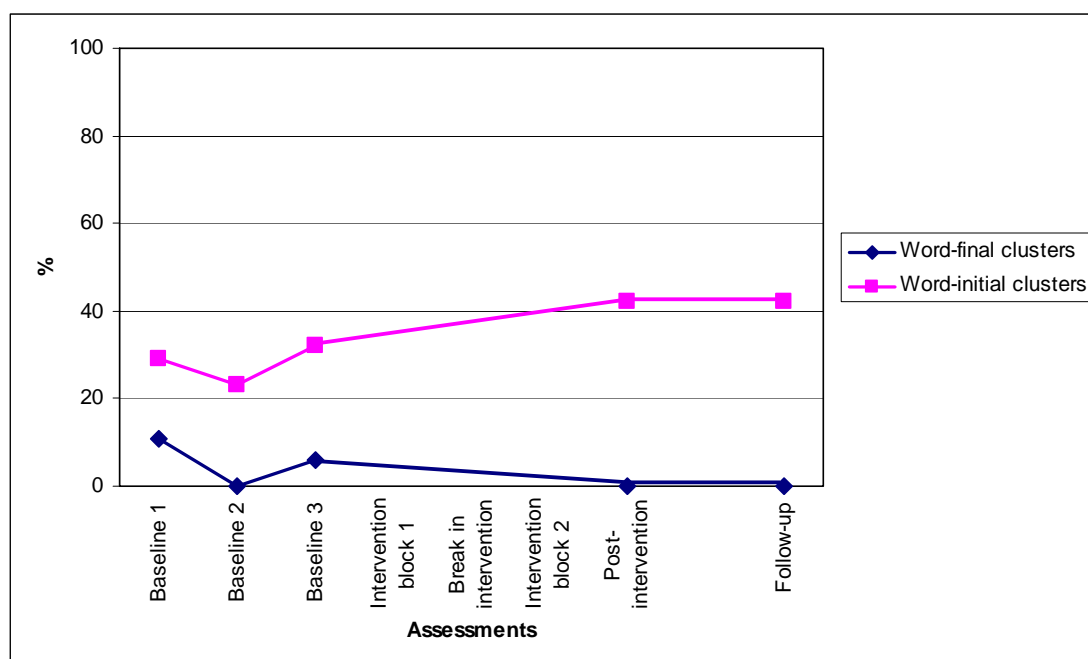
Word-final clusters

Mark produced only one correct word-final cluster (/mp/) during the baseline assessments. All other word-final clusters were reduced to a single element. The element deleted when the cluster was reduced did not appear to follow a consistent pattern. With some nasal + plosive clusters, the nasal consonant was retained (e.g., /nz/ reduced to [n]), with others the plosive was retained (e.g., /mp/ reduced to [p]), and occasionally there was a substitution for the retained element (e.g., /nt/ produced as a lateral fricative [ɲ]). The same variability was seen in his productions of plosive + fricative clusters (e.g., /ts/ to [s] and /ps/ to [p]) and plosive + plosive clusters (e.g.,

/pt/ to [p] and /kt/ to [t]). The two fricative + plosive clusters were reduced to retain the fricative consonant (e.g., /st/ to /s/).

When reassessed post-intervention and at follow-up three months post-intervention, none of the word-final clusters were produced accurately. Mark continued to reduce all word-final cluster attempts, with the phoneme retained for the target words generally the same as during the baseline assessments. This result indicates that any change in Mark's production of word-final clusters was not significant. The data for Mark that has been described above is summarised in Figure 5.

Figure 5. The percentage of accurate productions of word-final and word-initial consonant clusters by Mark.



Word-initial control clusters

Mark's word-initial cluster productions were much more accurate than his word-final clusters. There was also a greater shift towards more accurate word-initial cluster productions over the course of the study than for the word-final clusters.

During the baseline, Mark produced 29% (11/38) accurate word-initial clusters, higher than his accurate productions for word-final clusters (6% (1/17)). He correctly produced six different consonant clusters during the baseline assessments. These were plosive + /l/ clusters (/bl, pl, gl, kl/) and /s/ + nasal clusters (/sn, sm/). The word-initial /s/ clusters that were incorrectly produced were generally reduced to the second element with the /s/ deleted from the cluster (e.g., /sp/ to [p]). The incorrectly produced word-initial consonant + liquid clusters were often realised as clusters with substitution errors with substitutions that were unpredictable from his singleton productions (i.e. /fr/ produced as /fl/ when singleton /r/ was not realised as /l/). This occurred more often in the post-intervention and follow-up assessments than in the baseline assessments, with a change in the error pattern from clusters being reduced to a singleton to one or more consonants in the cluster being substituted.

When assessed post-intervention and at follow-up he produced 42% (22/53) word-initial clusters accurately. During the follow-up assessment he produced seven different word-initial clusters accurately. This improvement was significant.

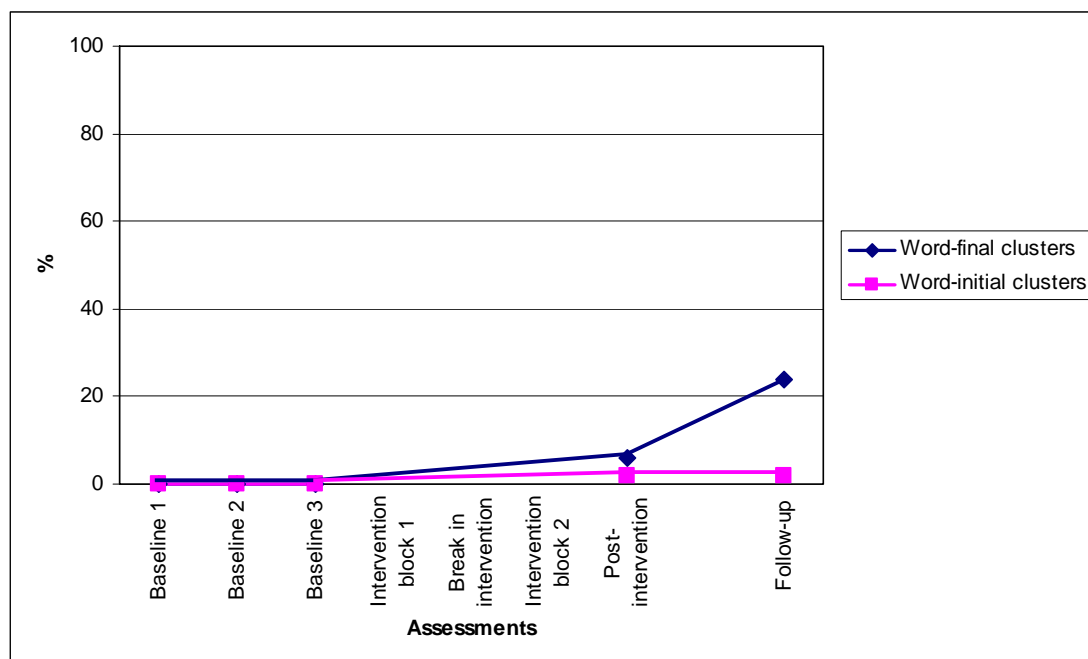
Participant : Mike

Word-final clusters

Mike produced all word-final clusters incorrectly in both spontaneous and imitated production attempts during the baseline measures. He reduced most word-final clusters to a singleton glottal stop and deleted the remaining clusters. Deletion of a consonant cluster is uncommon for children with typical development (Smit, 1993). It should be noted however, that this pattern reflected Mike's production attempts at word-final singletons as well as clusters. He occasionally produced word-final /n/ accurately, but words with other word-final phonemes were generally produced with a

glottal stop or no word-final consonant. The data for Mike that has been described above is summarised in figure 6.

Figure 6. The percentage of accurate productions of word-final and word-initial consonant clusters by Mike.



Mike produced one correct word-final cluster (/nt/) during the post-intervention assessment. At this stage, there were no instances where an entire word-final cluster was deleted. Most other word-final clusters were reduced to a single element. Word-final clusters containing nasal consonants were generally reduced with the nasal sound retained (e.g., /nz/ to [n], /mp/ to [m]), with two being produced as clusters with substitution errors with the target stop consonant substituted for a glottal stop (both /ŋk/ and /nt/ produced as /nʔ/). Other word-final clusters continued to be produced as a glottal stop.

When reassessed at follow-up three months post-intervention, 24% of word-final clusters were produced accurately. This was a significant improvement. Mike was more accurate with the word-final clusters containing nasal consonants, for which his productions had improved from the baseline assessments to the post-intervention reassessment. The correctly produced clusters at follow-up were /mp, nt, nz/. Two word-final clusters containing the phoneme /p/ were reduced to this sound during the follow-up assessment rather than to a glottal stop as during baseline and post-intervention assessments (i.e. /ps/ and /pt/ reduced to /p/). Other word-final cluster productions were reduced in the same way as during the post-intervention assessment. Mike reduced 85% of word-final clusters during the baseline assessments, which dropped to 65% during the follow-up assessment, due to increased accuracy of production for these clusters.

Word-initial control clusters

There was minimal change in Mike's production of the word-initial control clusters over the course of the intervention. Mike did not produce any word-initial clusters correctly during the baseline assessments, reducing all clusters to a single element. He reduced most /s/ + consonant clusters by deleting the /s/ and retaining the second element of the cluster (e.g., /st/ to /t/) and he reduced consonant + liquid clusters (including /sl/) by deleting the liquid element and retaining the first element of the cluster (e.g., /br/ to [b]).

During the post-intervention and follow-up assessments, Mike accurately produced only one word-initial cluster /fr/. This was not accurately produced for all /fr/ initial target words. The production of other word-initial clusters was consistent with the baseline productions.

Participant : Mary

Word-final clusters

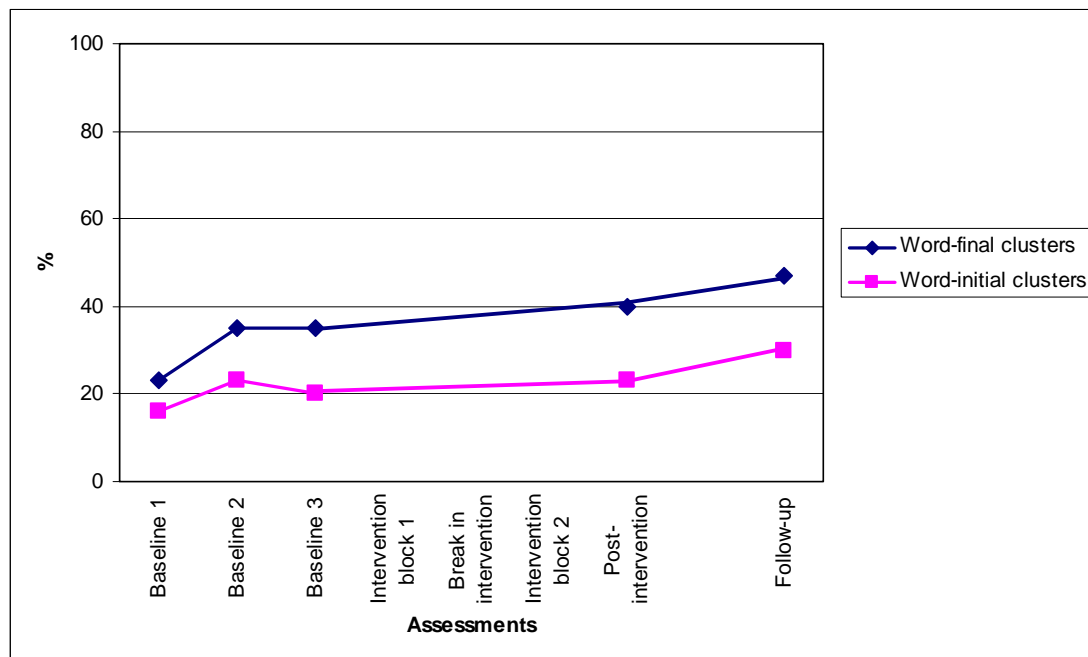
Mary's overall accuracy results for word-final cluster production showed little increase over the course of the study, with an average of 35% (6/15) correct productions at baseline, to 40% (6/17) post-intervention and 47% (8/17) at follow-up. This improvement in accuracy was significant.

During the baseline and post-intervention assessments, three different word-final clusters were produced accurately, with four different word-final clusters accurately produced in the follow-up assessment. The word-final nasal + plosive clusters /mp/ and /nt/ were accurately produced throughout the study, with more variation in the production attempts for other word final clusters. Other word-final clusters were reduced to a single element. Where the cluster contained a fricative /s/ or /z/, this was generally the element deleted from the cluster (e.g., /nz/ to [n], /st/ to [t], /ts/ to [t]).

There was a trend towards retaining two cluster elements and producing clusters with substitution errors in the follow-up assessment (e.g., /nz/ produced as [nt] and /kt/ produced as [ks]). Only 25% (4/16) of the word-final clusters were reduced to a single consonant during this follow-up assessment, compared to 56% (9/16) during the baseline measures. The number of clusters produced with substitution errors increased as the number of reductions decreased. During baseline, Mary produced only one word-final cluster with substitution errors (6% (1/16) occurrence). At follow-up, she produced 25% (4/16) of word-final clusters with substitution errors.

Metathesis occurred once during the baseline and once during follow-up assessment (e.g., /sk/ produced as /ks/ for the target *desk*). The data for Mary that has been described above is summarised in figure 7.

Figure 7. The percentage of accurate productions of word-final and word-initial consonant clusters by Mary.



Word-initial control clusters

During the baseline assessment Mary produced 20% (10/50) word-initial clusters accurately during the baseline assessments. The four accurately produced clusters were consonant + /l/ clusters (/pl, bl, kl fl/). Other consonant + /l/ clusters were realised as clusters with substitution errors (e.g., /gl/ produced as [bl] for target *glass*). There were varying realisations of other word-initial clusters. Most /s/ + consonant clusters were reduced to a single element with deletion of the /s/ from the cluster (e.g., /sm/ to [m] for target *smoke*). Consonant + /r/ word-initial cluster productions were generally reduced to a singleton phoneme by deleting the /r/ (e.g., /kr/ to [k] and /pr/ to [p]). There were also two examples of non-schwa epenthesis, where the two elements of the cluster were produced with a vowel between them (i.e. /bl/ produced as [bʌl] for target word *blue* and /sn/ produced as /sʌn/ for target word *snail*).

During the post-intervention assessment, 23% (12/53) of the word-initial cluster attempts were accurate. The same four clusters were produced correctly during this assessment, but they were more consistently accurate. Other productions were similar to those recorded at baseline.

When reassessed at follow-up Mary produced 30% (17/56) of the word-initial clusters correctly. This was a significant improvement compared to the baseline measures. Four new clusters were produced accurately (/kr, gr, tr, sp/) as well as those that were accurate during earlier assessments (/pl, bl, kl, fl/). The /s/ cluster /sp/ was only produced correctly for one out of five target words with this cluster during the assessment. The /s/ clusters were still mostly reduced to a single element, but /s/ was sometimes the phoneme retained at this stage (e.g., /sn/ to [s] for target word *snail*, /sl/ to [s] for target word *slip*). This may have been due to generalisation of the production of her speech target /s/ following intervention, however this had not generalised to the extent that the /s/ was being produced accurately in the majority of /s/ clusters. At this stage, nearly half (16/34) of her attempts at consonant + liquid clusters were accurate. Those that were incorrect, continued to be a mixture of reduction and substitution errors as seen in previous assessments.

Summary of cluster change for children in MA intervention

It was predicted that the children who received intervention targeted word-final morphemes would show improved accuracy of production for word-final clusters. This was predicted because the morphemes often create word-final clusters when added to a root word. It was hypothesised that the exposure to and practice in producing these word-final clusters during morphosyntax intervention would generalise to improved accuracy for word-final clusters.

The children who received language intervention targeting word-final morphemes did not show dramatic improvements in the accuracy of their productions of word-final clusters. However, the improvements of two of the children were significant. Mark's productions of these clusters remained inaccurate throughout the study. Mike's productions of word-final clusters remained inaccurate during the interventions, but the clusters with nasal phonemes improved following intervention. Mary's production accuracy on word-final clusters increased gradually over the course of the intervention at a similar rate to the untargeted word-initial clusters.

Comparison to alternative intervention

It was hypothesised that the word-final cluster productions for the children who received the PA intervention would not change. The children who received the phonological intervention with integrated speech targets did not have any direct intervention for word-final clusters. There was improvement in word-final cluster production for these children, but this was not a clear trend. There was great variation from child-to-child within this group. One child showed little change in production accuracy over the course of the study, one improved dramatically over the intervention period, and one improved slightly during the intervention and then accuracy improved dramatically for the follow-up assessment. All of these improvements were significant when compared to their baseline measures. This improvement in word-final cluster production may have been due to improvement made in word-initial /s/ clusters transferring to word-final clusters.

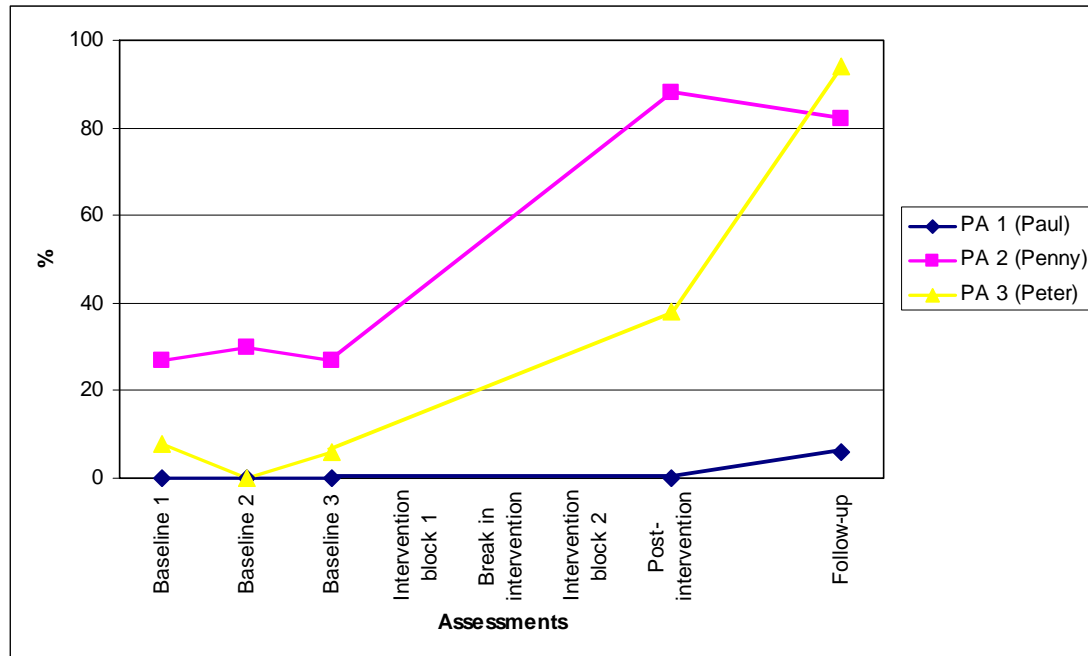
Paul showed little improvement in his accuracy with word-final clusters. At baseline and post-intervention he was inaccurate for all word-final clusters. In the follow-up assessments he produced one correct cluster, /ps/. His error productions did move closer towards accurate over the course of the study.

At baseline, he deleted on average 63% (10/16) of word-final clusters, this dropped to 31% (6/16) deleted post-intervention and to 18% (3/16) during the follow-up assessment. As the percentage of clusters Paul that deleted decreased, the percentage of cluster reduction increased. He started realising these clusters as single elements.

Penny's accuracy on word-final consonant clusters dramatically increased over the course of the intervention from an average of 33% (4/13) accurate during the baseline assessments, to 88% (15/17) post-intervention. This appeared to stabilise post-intervention, with little change from the post-intervention to the follow-up assessment (82% accurate (14/17)). During the baseline assessments, 60% of her word-final clusters were reduced to single elements. Cluster reduction occurred only once in the post-intervention and follow-up assessments.

Peter only produced the word-final cluster /mp/ accurately during the baseline assessments. At this stage, 80% (12/15) of error productions were reductions to a single element. During the post-intervention reassessment he produced 38% (7/16) word-final clusters accurately. The clusters produced correctly at this time were /mp, nt, pt, ŋk/. Although there were less error productions at this time, the percentage of errors that were reduced to singleton elements remained at 80% (8/10). When reassessed at follow-up, 94% (16/17) of the clusters were produced accurately, with no clusters reduced and one produced with substitutions that were not predictable from his singleton productions (/pt/ produced as /ps/ for target word *clapped*). See figure 8 for a summary of the results described above.

Figure 8. The percentage of accurate productions of word-final consonant clusters for participants Paul, Penny and Peter who received the phonological awareness with integrated speech practice intervention.



Summary

The second hypothesis considered the effect of intervention targeting word-final morphemes in the MA intervention on word-final consonant cluster production. It was predicted that the participants who received intervention targeting word-final morphemes (including the regular third person singular form of verbs, regular past tense of verbs, and copular form of the verb ‘to be’) would present with improved production of word-final clusters. Only 2 of the participants had significantly improved productions, and these improvements were not as great as for the children who had no intervention for word-final clusters. This data suggests that the improvement following the MA intervention was not conclusive. The hypothesis was partly confirmed by the data.

3.3 The impact of speech intervention for singleton phonemes on the production of those phonemes when produced in the context of a consonant cluster.

Hypothesis 3: That improved production of singleton phonemes will result in improved production of these target sounds in the context of consonant clusters.

The third hypothesis addressed the effect of speech intervention for singleton phonemes on the realisation of those phonemes when attempted in the context of a consonant cluster. It was predicted that improving accuracy of production for singletons would improve the participants' production of these phonemes in the context of clusters.

To address this hypothesis the accuracy of production of each participant's target singleton phonemes was compared to the production of these target phonemes in the context of consonant cluster production attempts. Comparisons were made for each child's productions at baseline, post-intervention, and at follow-up (3-months post-intervention).

Participant : Paul

Comparison of production of /p, t, n/ as word-final singletons and in consonant clusters

Paul had the word-final singleton phonemes /p, t, n/ as his integrated speech targets during the second cycle of phonological awareness intervention. His accuracy for singleton /p, t, n/ in word-final position increased from 26% (9/35) accuracy at baseline to 40% (6/15) accuracy for spontaneous productions at follow-up. Paul's accuracy of the /p, t, n/ elements in word-final cluster attempts increased at a similar rate from 29% (5/17) at baseline to 47% (8/17) at follow-up.

His error production attempts showed improvement towards more accurate production. For example, he deleted 71% (12/17) of the word-final /p, t, n/ clusters during baseline assessments, and only 18% (3/17) at follow-up.

His cluster productions did not always reflect increased accuracy for singleton productions. For example, at follow-up /n/ was accurately produced 66% (3/5) of the time as a word-final singleton, but was not retained in any of the reductions of word-final clusters to a single element. In contrast to this finding, no improvement was seen during the study for production of word-final /t/ as a singleton, but his realisation of /t/ in word-final clusters increased over the course of the study from 0% (0/11) at baseline to 66% (4/6) at follow-up. He was reasonably accurate in his production of word-final /p/ as a singleton and in the context of clusters throughout the study. See Table 7 for a summary of Paul's results.

Table 7

Accuracy on /p, t, n/ as word-final singletons and in word-final consonant clusters by Paul

	Baseline	Post-intervention	Follow-up
Word-final /p/	88% (7/8)	100% (5/5)	100% (2/2)
Word-final /t/	0% (0/11)	0% (0/7)	0% (0/7)
Word-final /n/	13% (2/16)	27% (3/11)	66% (4/6)
Word-final /p/ cluster	83% (5/6)	83% (5/6)	83% (5/6)
Word-final / t / cluster	0% (0/7)	0% (0/7)	43% (3/7)
Word-final /n/ cluster	0% (0/4)	0% (0/4)	0% (0/4)

Participant : Penny

Comparison of production of /r/ and /l/ as singletons and in consonant clusters

Penny had the word-initial singleton phonemes /l/ and /r/ as her integrated speech targets during the second cycle of phonological awareness intervention. Prior to intervention she primarily realised the phoneme /r/ as [w], and /l/ as either [j] or [w].

Penny's accuracy for the liquid elements of clusters followed her production of liquids as singletons. As her accuracy with /l/ and /r/ as singletons increased, so too did her accuracy when attempting these phonemes within clusters. At baseline she produced 4% (1/27) of word-initial liquid singletons and 8% (3/36) of liquid cluster elements correctly, post-intervention 31% (5/16) of singletons and 19% (7/36) of cluster elements were accurate, and at follow-up 100% (5/5) of singletons and 83% (30/36) of cluster elements were accurate. At baseline and post-intervention, Penny realised most consonant + liquid clusters as two-element clusters with substitutions for the liquid elements. Her substitution errors for liquid cluster elements were the same as for singletons. See Table 8 for a summary of Penny's results.

Table 8

Accuracy on liquid phonemes as singletons and in consonant clusters by Penny

	Baseline	Post-intervention	Follow-up
Word-initial /r/	0% (0/13)	50% (4/8)	100% (3/3)
Word-initial /l/	7% (1/14)	13% (1/8)	100% (2/2)
Consonant + /r/ cluster	20% (3/15)	47% (7/15)	87% (13/15)
Consonant + / l / cluster	0% (0/21)	0% (0/21)	81% (17/21)

Participant : Peter

Comparison of production of /k/ as a singleton and in consonant clusters

Peter had the singleton phoneme /k/ as his integrated speech target during the second cycle of phonological awareness intervention. Peter's production of /k/ in the context of clusters preceded his accurate production of /k/ as a singleton. He produced the voiced phoneme [g] in 66% (4/6) /k/ + liquid cluster attempts during the baseline, but substituted /k/ as a singleton with [t] or [d].

At baseline, he had 0% (0/41) accuracy with singleton /k/ productions and 38% (5/13) accuracy for /k/ cluster elements. Accurate productions were in word-initial clusters, as all word-final clusters were reduced with the /k/ element deleted.

Post-intervention Peter's production of /k/ in word-final position improved in both singleton productions and attempts at clusters. He accurately produced 57% (4/7) of word-final /k/ singletons and 75% (3/4) of /k/ cluster elements. Post-intervention he was still 0% (0/17) accurate for spontaneous word-initial /k/ singletons, however he was 81% (13/16) accurate for direct imitation productions. This showed improved ability to produce the sound despite this not having generalised to spontaneous productions. Peter's accuracy for /k/ in word-initial clusters did not improve in the post-intervention assessment.

At follow-up, he produced both /k/ in word-final clusters (2/4) and as a word-final singleton (1/2) with 50% accuracy. He had 20% (1/5) accuracy for /k/ as word-initial singletons and 66% (6/9) accuracy in word-initial clusters. He was 100% accurate for /k/ + liquid cluster /k/ elements, and 0% (0/3) accurate for /sk/ cluster /k/ elements. All /sk/ clusters were reduced to /s/, which is not the typical reduction pattern for /s/ clusters, but his increased awareness of the /s/ in the cluster may have

resulted from /st, sp, sl/ being targeted in the first intervention block. See Table 9 for a summary of Peter’s results.

Table 9

Accuracy on /k/ as a singleton and in consonant clusters by Peter

	Baseline	Post-intervention	Follow-up
Word-initial /k/	0% (0/29)	0% (0/17)	20% (1/5)
Word-final /k/	0% (0/12)	57% (4/7)	50% (1/2)
/k/ + liquid cluster	67% (4/6)	67% (4/6)	100% (6/6)
/sk/ cluster	33% (1/3)	0% (0/3)	0% (0/3)
Word-final /k/ cluster	0% (0/4)	75% (3/4)	50% (2/4)

Participant : Mark

Comparison of production of /k/ as a singleton and in consonant clusters

Mark had the singleton phoneme /k/ as his primary target for the articulation sessions of the morphosyntax intervention alternating with articulation therapy programme. His production of /k/ in the context of clusters changed in the same way as his productions of /k/ as a singleton. As his accuracy of word-initial /k/ singleton increased, so too did his accuracy of this phoneme when produced in word-initial clusters. His production of /k/ in word-final position moved from only fricative substitutions to a majority of stop substitutions, as did his realisation of /k/ in the context of clusters.

At baseline, Mark produced the singleton phoneme /k/ with 0% (0/40) accuracy. He substituted /k/ for [t] in word-initial position and [s] in word-final position. He produced /k/ with 7% (1/14) accuracy in the context of clusters.

Most word-initial /k/ clusters were reduced to the singleton substituted phonemes [t] or [d] and word-final clusters were reduced with the /k/ element deleted.

Post-intervention, his production accuracy increased for both singletons /k/ to 38% (6/16) and cluster element /k/ to 60% (6/10) in word-initial position. He was inaccurate for all word-final singleton and cluster element productions.

At follow-up, though assessed with fewer words, this pattern continued. He produced word-initial /k/ with variable accuracy and substituted word-final /k/ with [t] or [s]. He produced /k/ with 21% (3/14) accuracy in the context of clusters. Mark's accurate production of the /k/ element was only for /k/ + liquid clusters. See Table 10 for a summary of Mark's results.

Table 10

Accuracy on /k/ as a singleton and in consonant clusters by Mark

	Baseline	Post-intervention	Follow-up
Word-initial /k/	0% (0/28)	38% (6/16)	50% (2/4)
Word-final /k/	0% (0/12)	0% (0/7)	0% (0/2)
Word-initial /k/ cluster	10% (1/10)	60% (6/10)	33% (3/10)
Word-final /k/ cluster	0% (0/4)	0% (0/3)	0% (0/4)

Participant : Mike

Comparison of production of /p, t, n/ as word-final singletons and in consonant clusters

Mike had the word-final singleton phonemes /p, t, n/ as his targets for the speech sessions of the integrated morphosyntax intervention alternating with articulation therapy. For this analysis, the realisation of word-final /t/ as the glottal stop [ʔ] was scored as accurate, as this is commonly seen in adult productions in

connected speech. His production of word-final /p, t, n/ as singletons and in the context of word-final clusters changed in similar ways over the course of the study. His accuracy for /n/ as a word-final singleton and as an element in a word-final cluster improved from almost none at baseline to 100% accurate at follow-up assessment. His accuracy for word-final /t/ was high for cluster and singleton attempts for all assessments. He showed greater improvement for word-final /p/ as a singleton (from 0% (0/8) at baseline to 100% (2/2) at follow-up) than for word-final /p/ as a cluster element (from 0% (0/5) at baseline to 50% (3/6) at follow-up). His improved production for the cluster element appeared to be following the singleton accuracy.

During baseline assessment, 9% (3/35) of target word-final phonemes were produced accurately and 77% (27/35) were deleted. During the baseline measures, Mike only produced the cluster element /t/ accurately (100% (6/6)). Most word-final clusters were reduced to a substituted glottal stop, but this was only scored correctly for attempts at the phoneme /t/.

Post-intervention, his accuracy for word-final /n/ increased to 82% (9/11), with 20% (1/5) accuracy for word-final /p/ and 86% (6/7) for /t/. During this assessment less word-final /p, t, n/ attempts (17% (4/23)) were deleted. Post-intervention he produced 59% (10/17) word-final cluster elements correctly, with the biggest improvement observed in /n/ cluster elements (from 0% (0/3) at baseline to 75% (3/4) post-intervention).

During the follow-up assessment, Mike produced all of the word-final singleton targets accurately (100% 11/11) and also showed improvement in his productions of word-final cluster elements (76% (13/17)). See Table 11 for a summary of Mike's results.

Table 11

Accuracy on /p, t, n/ as word-final singletons and in word-final consonant clusters by Mike

	Baseline	Post-intervention	Follow-up
Word-final /p/	0% (0/8)	20% (1/5)	100% (2/2)
Word-final /t/	18% (2/11)	86% (6/7)	100% (3/3)
Word-final /n/	6% (1/16)	82% (9/11)	100% (6/6)
Word-final /p/ cluster	0% (0/5)	17% (1/6)	50% (3/6)
Word-final /t/ cluster	100% (6/6)	86% (6/7)	86% (6/7)
Word-final /n/ cluster	0% (0/3)	75% (3/4)	100% (4/4)

Participant : Mary

Comparison of production of /s/ as a singleton and in consonant clusters

Mary had the singleton phoneme /s/ as her primary target for the speech sessions of the morphosyntax intervention alternating with articulation therapy. This was selected because she often stopped fricative sounds in initial and final positions in words (e.g., *sun* became [tʌn] and *goose* became [gut]). Overall, less change was seen in the accuracy of production of /s/ in the context of clusters than as a singleton.

At baseline, she produced 13% (3/23) of word-initial /s/ singletons and 0% (0/6) of word-final singletons correctly. The majority of errors were substitutions for [t]. Occasionally the /s/ was produced as well as this substitution, resulting in the formation of the cluster [ts] (e.g., *mouse* produced as [mæts] and *sad* produced as [tsæd]). At baseline she accurately produced 8% (2/24) of /s/ cluster elements. She

generally deleted the /s/ by reducing the cluster, rather than substituting it with a stop as might be predicted by her production of singletons.

During the post-intervention assessment, Mary was accurate with 33% (7/21) of her attempts at singleton /s/. Her error substitutions were more variable during this assessment, as she substituted /s/ for [t], [ts], [ʔs] and [□]. When reassessed post-intervention, she produced the /s/ element for 30% (6/20) word-initial /s/ clusters when reducing them to a singleton element. This is not a common reduction pattern for children with typical development (Smit, 1993), however Hodson (2007) reported this reduction pattern for children with speech sound disorder following intervention for the singleton /s/.

When reassessed at follow-up, Mary was 92% (12/13) accurate for singleton /s/ productions. Her accuracy at follow-up for word-initial /s/ was now established and this accuracy had generalised to word-final /s/ productions. In contrast, there was little change in Mary's realisation of /s/ in word-initial clusters with 36% (10/28) accuracy for /s/ elements. See Table 12 for a summary of Mary's results.

Table 12

Accuracy on /s/as a singleton and in consonant clusters by Mary

	Baseline	Post-intervention	Follow-up
Word-initial /s/	13% (3/23)	47% (7/15)	100% (7/7)
Word-final /s/	0% (0/6)	0% (0/6)	83% (5/6)
Word-initial /s/ cluster	6% (1/18)	30% (6/20)	27% (6/22)
Word-final /s/ cluster	17% (1/6)	25% (1/4)	66% (4/6)

Summary

The third hypothesis considered changes in the accuracy of cluster element production following intervention targeting those elements as singletons. It was hypothesised that improved production of singleton phonemes would result in improved production of these target sounds in the context of consonant clusters for children in both intervention groups. The data supported this hypothesis.

Chapter 4

Discussion

This study examined the effect of two different types of intervention on the cluster production of a group of 4-year-old children with speech sound disorder and expressive language difficulties. The children's cluster productions were recorded pre-intervention, immediately post-intervention and at follow-up 3 months post-intervention. All children received 24 therapy sessions with either a phonological awareness with integrated speech target intervention or intervention which combined morphosyntax language work and traditional speech articulation therapy. Therapy was administered in two blocks of 6 weeks with two therapy sessions a week in small group settings. The phonological awareness intervention aimed to improve speech intelligibility and phonological awareness skills by targeting speech sounds, letter knowledge, and phoneme awareness. The morphosyntax intervention aimed to improve speech intelligibility and expressive language skills by targeting speech sounds, morphosyntactical awareness, and grammatical morpheme use.

4.1 Hypothesis 1

The first hypothesis considered the effect of treating /s/ clusters in the PA intervention on word-initial consonant cluster production. There were three predictions made in this hypothesis. First, it was predicted that this intervention would result in improved production of the target /s/ clusters. This hypothesis was supported by the data as significant improvements in production were seen for all three participants. Greater improvement was seen in productions of the target /s/ clusters for the participants who received therapy targeting /s/ clusters in the PA intervention than for those who received the MA intervention with no therapy for word-initial /s/ clusters. This finding is consistent with Gillon's (2000) findings that it is possible to integrate speech targets into a phonological awareness intervention approach and achieve improvements in the child's speech production.

Two of the three participants (Paul and Peter) who received the phonological intervention produced spontaneous productions much less accurately than for imitated productions during follow-up. These data indicate that during the period where a consonant cluster is 'new' following intervention and is still being produced variably, more accurate productions can be seen with direct imitation. Kirk and Demuth (2005) found no difference between imitation and spontaneous productions in their 2-year old participants with typical development. This difference may indicate that children with speech sound disorder may need more modelling of newly learned clusters to help establish them in their speech.

Hodson (1991) recommended not targeting any /s/ + consonant clusters for which the consonants are not stimuable. Penny was not stimuable for the phoneme /l/ prior to intervention and showed no improvement in her production of /sl/ clusters following intervention targeting /st, sp, sl/. She did however, show improved accuracy

of /l/ in the context of /sl/ clusters having had intervention for the liquids /r/ and /l/ as singletons in the second block of intervention. This finding supports Hodson's view that stimulability should be a consideration when selecting which /s/ clusters to treat in intervention. It contrasts with the complexity approach (Gierut, 1998a; Miccio & Ingrisano, 2000; Williams, 1991), that suggests greatest improvement can be seen when a sound is targeted for which the child has least phonological knowledge (e.g., the sound is not stimutable).

It was further predicted that therapy for the word-initial clusters /st, sp, sl/ in the PA intervention would generalise to accurate production of non-target /s/ clusters (e.g., /sn, sm, sk, sw/). This prediction was also supported by the data as significant improvements were made by the two participants who had difficulty with production pre-intervention. The two participants (Paul and Peter) who initially had 0% accuracy for productions of non-target /s/ clusters had improved accuracy following intervention. The major shift in accuracy occurred between the post-intervention assessment and the follow-up assessment. This suggests that the productions of these participants went through a transfer phase after being established during intervention (Bernthal & Bankson, 2004). Generalisation following intervention may reflect encouragement from parents in the home environment. Dodd (2005) suggested that compared to the time spent in other environments, therapy time is very restricted and input from teachers and parents is essential to ensure generalisation to environments outside the clinic. Despite the fact that homework was not prescribed as part of the intervention, many of the activities used in therapy were simple, fun and easily replicable. Parents watched the sessions from the observation room and may have tried activities or continued to praise production attempts at home. Future research needs to examine more closely the influence of the home environment on speech

treatment effects. The third participant in this treatment condition produced the non-target /s/ clusters accurately throughout the study.

The third prediction related to this first hypothesis was that therapy for /st, sp, sl/ in the PA intervention would generalise to accurate production of singleton fricatives. This was predicted based on the findings of Gierut (1999; 2001) and Hodson (2007), who both reported improved accuracy for singleton fricative production following intervention for /s/ clusters.

This prediction was supported by the data. Although the improvements in accuracy were not as great as for the target /s/ clusters, they were significant for all three participants.

4.2 Hypothesis 2

The second hypothesis considered the effect of intervention targeting word-final morphemes in the MA intervention on word-final consonant cluster production. It was predicted that the participants who received intervention targeting word-final morphemes (including the regular third person singular form of verbs, regular past tense of verbs, and copular form of the verb ‘to be’) would present with improved production of word-final clusters. This was hypothesised, as many target structures involved the production of word-final clusters (WFC) (e.g., ‘makes’ has WFC /ks/, ‘looked’ has WFC /kt/, and ‘it’s’ has WFC /ts/).

Overall, the data did not support this hypothesis. Two participants (Mike and Mary) had significant improvements in their accuracy for word-final clusters at follow-up. However, this improvement in accuracy was less than the improvements made by two of the control children from the PA group, who did not receive intervention for word-final morphemes. The other child who received the MA

intervention showed improvement in the untargeted word-initial clusters, but was inaccurate for word-final clusters throughout the study.

This suggests that participants' word-final clusters were not generally facilitated through the implicit auditory exposure and motor practice (where the focus is on the morpheme rather than the cluster) received in the MA programme. They may require more explicit learning (i.e. learning with attention on target sounds and structures) to ensure these clusters are learned.

Velleman and Vihman (2002) stated that children with speech sound disorder may benefit from intensive exposure to a structure they do not use. They also suggested that some children may have knowledge of a structure, but still not use it. Therefore, this exposure may not be enough to facilitate use of the structure. In these cases, explicit teaching of the target is required. The explicit teaching in this programme was not for word-final clusters, but for morphemes. The children may require a combination of implicit and explicit learning to facilitate accurate production of word-final cluster targets.

4.3 Hypothesis 3

The third hypothesis considered changes in the accuracy of cluster element production following intervention targeting those elements as singletons. It was hypothesised that providing opportunities to improve the production of singleton phonemes in both the phonological awareness and language interventions would result in improved production of these target sounds in the context of consonant clusters.

The data supported this hypothesis. All participants showed improved accuracy in the production of singleton targets when attempted as cluster elements during the follow-up assessment. For some children (e.g., Mike and Penny) their

accuracy improved for singleton consonants before accuracy for cluster elements. For other children (e.g., Mark, Peter and Paul), the accuracy for the target phonemes improved at a similar rate for both singleton and cluster element productions.

For the final participant (Mary), accuracy was higher for word-final /s/ clusters than singletons pre-intervention, and accuracy improved for /s/ in both of these contexts.

In contrast, less improvement was seen in her production of /s/ in word-initial clusters than in her word-initial singleton attempts. This is due to her continuing to reduce word-initial /s/ clusters to a singleton phoneme. However, she started occasionally reducing /s/ clusters to a singleton /s/ on occasion rather than deleting the /s/ as is the case in typical reduction patterns for /s/ clusters. Hodson (2007) reported that children who have had intervention for /s/ as a singleton may start reducing /s/ clusters in this way, rather than adding the /s/ to the previous realisation. The data for this participant supports the suggestion that children with speech sound disorder may not use /s/ in the context of clusters despite being able to use produce it as a singleton, and the argument that specific instruction for production within consonant clusters may be necessary.

4.4 Findings

The first major finding from this study is that intervention for /s/ clusters provided using the PA programme resulted in greater improvements in cluster accuracy than the MA approach which targeted word-final morphemes. This suggests that explicit teaching of consonant cluster structures results in greater improvement in cluster production than is seen with implicit learning. The extent of improvement in accuracy was not evident immediately post-intervention, with most of the generalisation occurring in the 3-month period following therapy. During this

generalisation period, it appears that direct imitation elicits the most accurate productions for children with speech sound disorders. These children were not able to imitate /s/ clusters pre-intervention. Some improvement was seen in the production of the untreated consonant + liquid clusters for two of the PA children, but this improvement was much less than for the target /s/ clusters.

The second major finding was that intervention for word-final morphemes which often result in the creation of word-final clusters (e.g., [ps] in *lips*, [ks] in *likes*, [pt] in *clapped*) is not sufficient to improve the production accuracy of word-final clusters. Using this intervention may help to raise children's awareness of the morphemes, but more direct intervention for cluster structures is required to help this knowledge generalise into accurate production attempts.

The third major finding from this study is that targeting most singleton phonemes resulted in improvements in the production of these phonemes when attempted as cluster elements. This was less evident for word-initial /s/. The production of /s/ in the context of word-initial clusters improved much more rapidly with direct intervention, than waiting for generalisation from accuracy as a singleton.

4.5 Limitations

The findings from this study should be interpreted cautiously due to the small sample size. Furthermore, the individual variation between the participants involved in this study should be considered. There were differences in the participants' levels of phonological awareness, speech production accuracy and expressive language pre-intervention. In future studies, it may be possible to select the intervention that is considered to more likely to result in improvement for an individual child. This was not possible for the current study due to the randomised allocation process. In many respects the participants' speech and language skills pre-intervention have confirmed

that the population of children with speech sound disorder and coexisting language disorder are a very heterogeneous group.

The current study only considers changes in cluster production for the participants and does not evaluate the extent of improvement in other areas of speech and language. Improvements in phonological awareness, expressive language (especially use of morphemes), and overall speech measures are not presented in this study. Change in cluster production is a specific area of speech development which is of interest as it has not been directly considered in light of different treatment techniques. However, these changes would benefit from further scrutiny in relation to improvements in the language targets (i.e. phonological awareness and expressive morpheme use), and overall improvement in speech production. Improvement in consonant cluster production was not the only target for these intervention programmes and as such, improvement in cluster production alone is not an indication that one treatment programme is more effective than another for the child's broader linguistic development. The study currently in progress (Gillon et. al, 2007) will further address the efficacy of these interventions for improving phonological awareness, expressive morpheme use, and the speech system as a whole.

4.6 Clinical Implications

The findings from this study suggest that greater improvement in accuracy of cluster production for children with speech sound disorder can be expected following a phonological awareness and integrated speech programme, than following a morphosyntax programme integrated with articulation therapy. Improvement in cluster production was not seen through implicit learning during this study. The

phonological awareness programme directly targeted increasing the child's awareness of cluster elements in word-initial /s/ clusters. The structure of the clusters was discussed, with opportunities through whiteboard activities for manipulation of cluster elements, and there were many opportunities for production practice in this intervention. This study supports previous findings that consonant clusters need to be selected as speech targets to ensure improved accuracy of production.

4.7 Future Directions

Further research investigating and comparing the impact of other interventions that explicitly target consonant clusters would be beneficial. Research has established that targeting clusters in intervention can lead to improvements across the phonological systems of children of children with speech sound disorder (Gierut, 1998a; 2001; Gierut & O'Connor, 2002). This study has supported the argument that consonant clusters should be a treatment goal since children with speech sound disorder require explicit teaching for improvement in consonant cluster production. Continued research is needed to explore which clusters will lead to the greatest generalisation when selected for therapy targets and which intervention methods used are the most efficient for the individual children receiving therapy.

4.8 Conclusion

This study has examined the effect of two different intervention approaches on the cluster production of 4-year-old children with speech sound disorder. The data showed that the Gillon and Morairty (2005) phonological awareness intervention programme with integrated speech targets lead to significant improvement in production of the target /s/ clusters, and generalised to increased accuracy for productions of singleton fricatives, non-target /s/ clusters, and untreated consonant +

liquid clusters. This intervention explicitly targeted word-initial /s/ clusters during intervention.

The Haskil et al. (2001) morphosyntax programme alternating with articulation therapy for singleton targets resulted in less consistent improvement in production for target word-final clusters. In this programme, word-final clusters were implicitly treated through language intervention for word-final morphemes. This data indicates that improvement in consonant cluster production is facilitated when using explicit teaching methods to introduce and practice consonant clusters during intervention with children with speech sound disorder.

References

- Beitchman, J., Nair, R., Clegg, M., & Patel, P. (1986). Prevalence of speech and language disorders in 5-year-old kindergarten children in the Ottawa-Carleton Region. *Journal of Speech and Hearing Disorders, 51*, 98-110.
- Bernthal, J., & Bankson, N. (2004). *Articulation and phonological disorders* (5th ed.). Boston, MA: Allyn and Bacon
- Bernthal, J. B., & Bankson, N. (1998). *Articulation and phonological disorders*. (4th ed.). Boston: Allyn and Bacon.
- Beukelman, D., Jones, R., & Rowan, M. (1989). Frequency of word usage by nondisabled peers in integrated preschool classrooms. *Augmentative and Alternative Communication, 5*, 243-248.
- Bleile, K. (1995). *Manual of articulation and phonological disorders*. San Diego: Singular Publishing Group.
- Broomfield, J., & Dodd, B. (2004). Children with speech and language disability: case-load characteristics. *International Journal of Language and Communication Disorders, 39*(3), 303-324.
- Carrow-Woolfolk, E. (1995). *Oral and Written Language Scales: Listening Comprehension and Oral Expression*. Circle Pines, MN: American Guidance Service.
- Carrow-Woolfolk, E. (1999). *CASL: Comprehensive Assessment of Spoken Language*. Circle Pines, MN: American Guidance Service, Inc.
- Chin, S. B., & Dinnsen, D. A. (1992). Consonant clusters in disordered speech - Constraints and correspondence patterns. *Journal of Child Language, 19*(2), 259-285.

- Crosbie, S., Holm, A., & Dodd, B. (2005). Intervention for children with severe speech disorder: A comparison of two approaches. *International Journal of Language & Communication Disorders*, 40(4), 467-491.
- Crystal, D. (1986). *Listen to your child: A parent's guide to children's language*. London: Penguin Books.
- Dawson, J., Stout, C., Eyer, J., Tattersall, M., Fonkalsrud, M., & Croley, M. (2004). *Structured Photographic Expressive Language Test - Preschool 2*. DeKalb, IL: Janelle Publications.
- Dodd, B., & Bradford, A. (2000). A comparison of three therapy methods for children with different types of developmental phonological disorder. *International Journal of Language & Communication Disorders*, 35(2), 189-209.
- Dodd, B., Hua, Z., Crosbie, S., Holm, A., & Ozanne, A. (2002). *Diagnostic Evaluation of Articulation and Phonology*. London: The Psychological Corporation.
- Dyson, A. T. (1988). Phonetic Inventories of 2-Year-Old and 3-Year-Old Children. *Journal of Speech and Hearing Disorders*, 53(1), 89-93.
- Elbert, M., Dinnsen, D. A., & Powell, T. W. (1984). On the Prediction of Phonologic Generalization Learning-Patterns. *Journal of Speech and Hearing Disorders*, 49(3), 309-317.
- Fried-Oken, M., & More, L. (1992). An initial vocabulary for nonspeaking preschool children based on developmental and environmental language scores. *Augmentative and Alternative Communication*, 8, 41-56.
- Gierut, J. (1998a). Natural domains of cyclicity in phonological acquisition. *Clinical linguistics and phonetics*, 12(6), 481-499.

- Gierut, J. (1998b). Treatment efficacy: Functional phonological disorders in children. *Journal of Speech, Language, and Hearing Research*, 41(1), S85-S100.
- Gierut, J. A., & Champion, A. H. (2001). Syllable onsets II: Three-element clusters in phonological treatment. *Journal of Speech, Language, and Hearing Research*, 44(4), 886-904.
- Gierut, J. A., & O'Connor, K. M. (2002). Precursors to onset clusters in acquisition. *Journal of Child Language*, 29(3), 495-517.
- Gillon, G. (2000). The efficacy of phonological awareness intervention for children with spoken language impairment. *Language, Speech, and Hearing Services in Schools*, 31, 126-141.
- Gillon, G. (2002). Follow-up study investigating benefits of phonological awareness intervention for children with spoken language impairment. *International Journal of Language and Communication Disorders*, 37(4), 126-141.
- Gillon, G. (2004). *Phonological awareness: From research to practice*. New York, NY: The Guilford Press
- Gillon, G. (2005). Facilitating phoneme awareness development in 3- and 4-year old children with speech impairment. *Language, Speech, and Hearing Services in Schools*, 36(4), 308-324.
- Gillon, G., & Moriarty, B. (2005). *Integrated phonological awareness: An intervention programme for preschool children with speech-language impairment*. Christchurch: University of Canterbury.
- Gillon, G., & Moriarty, B. (2006). *Evidence based practice: An update of best practices in Speech-Language Therapy*. Wellington: New Zealand Ministry of Education.

- Gillon, G., & Schwarz, I. (1999). *Resourcing speech and language needs in Special Education: Database and best practice validation*. Wellington: Ministry of Education.
- Gillon, G., Tyler, A., & Schwarz, I. (2007). The efficacy of phonological awareness treatment for children with speech and language impairment. *Manuscript in preparation*.
- Goldman, R., & Fristoe, M. (1972). *Goldman-Fristoe Test of Articulation*. Circle Pines, MN: American Guidance Service.
- Greenlee, M. (1974). Interacting processes in the child's acquisition of stop-liquid clusters. *Papers and Reports on Child Language Development*, 7, 85-100.
- Grunwell, P. (1982). *Clinical phonology*. London: Croom Helm.
- Haskill, A., Tyler, A., & Tolbert, L. (2001). *Months of morphemes: A theme-based cycles approach*. Eau Claire, Wisconsin: Thinking Publications.
- Hodson, B. W. (2004). *Hodson Assessment of Phonological Patterns*. Austin: Pro-Ed.
- Hodson, B. W. (2007). *Evaluating and enhancing children's phonological systems: Research and theory into practice*. Greenville: Thinking publications University.
- Hodson, B. W., & Paden, E. (1981). Phonological processes which characterize unintelligible and intelligible speech in early childhood. *Journal of Speech and Hearing Disorders*, 46, 369-373.
- Hodson, B. W., Scherz, J. A., & Strattman, K. H. (2002). Evaluating communicative abilities of a highly unintelligible preschooler. *American Journal of Speech-Language Pathology*, 11(4), 236-242.
- Hodson, B. W. P., E. (1991). *Targeting intelligible speech: A phonological approach to remediation*. Austin: Pro-Ed.

- Hogan, T., Catts, H., & Little, T. (2005). The relationship between phonological awareness and reading: Implications for the assessment of phonological awareness. *Language, Speech, and Hearing Services in Schools*, 36(4), 285-293.
- Kahmi, A., & Pollock, K. (2005). *Phonological disorders in children*. Baltimore: Paul H Brookes Publishing Co.
- Kirk, C. (2007). Substitution errors in the production of word-initial and word-final consonant clusters. *Manuscript submitted for publication*.
- Kirk, C., & Demuth, K. (2005). Asymmetries in the acquisition of word-initial and word-final consonant clusters. *Journal of Child Language*, 32(4), 709-734.
- Larrivee, L., & Catts, H. (1999). Early reading achievement in children with expressive phonological disorders. *American Journal of Speech-Language Pathology*, 8(2), 118-128.
- Levelt, C., Schiller, N., & Levelt, W. (1999-2000). The acquisition of syllable types. *Language Acquisition*, 8(3), 237-264.
- Lleo, C., & Prinz, M. (1996). Consonant clusters in child phonology and the directionality of syllable structure assignment. *Journal of Child Language*, 23(1), 31-56.
- Long, S., Fey, M., & Channell, R. (1999). Computerized profiling (MS-DOS version 9.0). Cleveland, OH: Case Western Reserve University.
- McLeod, S., van Doorn, J., & Reed, V. A. (2001a). Consonant cluster development in two-year-olds: General trends and individual difference. *Journal of Speech, Language, and Hearing Research*, 44(5), 1144-1171.
- McLeod, S., van Doorn, J., & Reed, V. A. (2001b). Normal acquisition of consonant clusters. *American Journal of Speech-Language Pathology*, 10(2), 99-110.

- McLeod, S., van Doorn, J., & Reed, V. A. (1997). Realizations of consonant clusters by children with phonological impairment. *Clinical Linguistics & Phonetics*, 11(2), 85-113.
- Miccio, A. W., & Ingrisano, D. R. (2000). The acquisition of fricatives and affricates: Evidence from a disordered phonological system. *American Journal of Speech-Language Pathology*, 9(3), 214-229.
- Portney, L., & Watkins, M. (2000). *Foundations of clinical research: Applications to practice* (2nd ed.). Upper Saddle River, NJ: Prentice Hall Health.
- Powell, T. W., & Elbert, M. (1984). Generalization following the remediation of early-developing and later-developing consonant clusters. *Journal of Speech and Hearing Disorders*, 49(2), 211-218.
- Preisser, D. A., Hodson, B. W., & Paden, E. P. (1988). Developmental Phonology - 18-29 Months. *Journal of Speech and Hearing Disorders*, 53(2), 125-130.
- Rvachew, S., & Grawburg, M. (2006). Correlates of phonological awareness in preschoolers with speech sound disorders. *Journal of Speech, Language, and Hearing Research*, 49(1), 74-87.
- Rvachew, S., & Nowak, M. (2001). The effect of target-selection strategy on phonological learning. *Journal of Speech, Language, and Hearing Research*, 44(3), 610-623.
- Schwarz, I., & Gillon, G. (1998). A review of best practices and service needs in speech-language therapy: Results of SE 2000 speech-language initiative research projects. *New Zealand Journal of Speech-Language Therapy*, 52, 22-32.

- Shriberg, L., Austin, D., Lewis, B., McSweeny, J., & Wilson, D. (1997). The speech disorders classification system (SDCS): Extensions and lifespan reference data. *Journal of Speech, Language, and Hearing Research*, 40(4), 723-740.
- Shriberg, L., Tomblin, J., & McSweeny, J. (1999). Prevalence of speech delay in 6-year-old children and comorbidity with language impairment. *Journal of Speech, Language, and Hearing Research*, 42(6), 1461-1481.
- Smit, A. B. (1993). Phonological error distributions in the Iowa-Nebraska articulation norms project - Word-initial consonant clusters. *Journal of Speech and Hearing Research*, 36(5), 931-947.
- Stackhouse, J., Wells, B., Pascoe, M., & Rees, R. (2002). From phonological therapy to phonological awareness. *Seminars in Speech and Language* 23(1), 27-42.
- Stoel-Gammon, C. (1987). Phonological skills of 2-year-olds. *Language, Speech, and Hearing Services in Schools*, 18(4), 323-329.
- Stoel-Gammon, C., & Dunn, C. (1985). *Normal and disordered phonology in children*. Austin: Pro-Ed.
- Tyler, A. (2002). Language-based intervention for phonological disorders. *Seminars in Speech and Language*, 23(1), 69-81.
- Tyler, A., Lewis, K., Haskill, A., & Tolbert, L. (2003). Outcomes of different speech and language goal attack strategies. *Journal of Speech, Language, and Hearing Research*, 25, 215-234.
- Tyler, A. A., Lewis, K. E., Haskill, A., & Tolbert, L. C. (2002). Efficacy and cross-domain effects of a morphosyntax and a phonology intervention. *Language, Speech, and Hearing Services in Schools*, 33(1).

- Tyler, A. A., Lewis, K. E., & Welch, C. M. (2003). Predictors of phonological change following intervention. *American Journal of Speech-Language Pathology*, 12(3), 289-298.
- Velleman, S., & Vihman, M. (2002). Whole-word phonology and templates: Trap, bootstrap, or some of each? *Language, Speech, and Hearing Services in Schools*, 33(1), 9-23.
- Wechsler, D. (1991). *Wechsler Intelligence Scale for Children* (3 ed.). San Antonio, TX: The Psychological Corporation.
- Wiig, E., Secord, W., & Semel, E. (1992). *The clinical evaluation of language fundamentals - Preschool*. San Antonio, TX: The Psychological Corporation.
- Williams, A. (1991). Generalisation patterns associated with training least phonological knowledge. *Journal of Speech and Hearing Research*, 34, 722-733.
- Wyllie-Smith, L., McLeod, S., & Ball, M. J. (2006). Typically developing and speech-impaired children's adherence to the sonority hypothesis. *Clinical Linguistics & Phonetics*, 20(4), 271-291.
- Yavas, M. (1998). *Phonology development and disorders*. San Diego: Singular Publishing Group Inc.

Appendices

Appendix A

Target words for consonant cluster probes

<i>Word initial clusters</i>		
stop + /r/	(pr, br, kr, gr, tr, dr)	pram
		brush
		crab, crocodile
		grasshopper
		tractor, tree, train
		drum
stop + /l/	(pl, bl, kl, gl)	plane, plum, plant, plate
		block, blocks
		cloud
		glue, glass
fricative + /l/	(fl)	flag, flower, fly
fricative + /r/	(fr)	frog, fruit
/s/ + plosive	(sp, st, sk)	spot, spoon, spin, spiderman, spider
		star, stingray, stir
		skate, skeleton, skateboard, skunk
/s/ + nasal	(sm, sn)	smoke
		snail, snow, Snoopy, snake
/s/ + liquid	(sl)	slow, sleep

Word final clusters

nasal + fricative	(ŋz, ns, mz)	beans
		wings
plosive + plosive	(pt, kt)	clapped
		licked
nasal + plosive	(nt, nd, mp)	paint, plant
		lamp
		skunk
fricative + plosive	(st, sk)	nest
		desk
plosive + fricative	(ps, ts)	lips
		boots
		blocks

/s/ singleton words

/s/-initial	sad, saw, soup, sun, seal
/s/-final	bus, house, mess, mouse, goose

Appendix B

Activity examples for the phonological awareness with integrated speech targets intervention programme

1) *Phoneme awareness and identity*

- a. Matching items or target words to others that start or end with the same phoneme e.g., *Phoneme categorisation*.

Therapist: This is my dog *Spot*. *Spot's* name has the /s/ sound at the beginning. Let's something for *Spot* to eat that has a /s/ at the beginning too. Which one starts with /s/...popcorn, sandwich, or muffin? Listen for the /s/ sound at the start.

- b. Deciding which phoneme a word a word starts or ends with from the selection provided by therapist e.g., *Mystery Bag*.

Therapist: You pulled a *key* out of the bag. Does *key* start with /k/ or /m/?

- c. Finding an item that starts or ends with a phoneme provided e.g., *I spy*. Therapist: I spy with my little eye, something beginning with /s/. Who can find a picture that starts with /s/? That's right *star* has /s/ at the beginning, great listening for the /s/ sound!

- d. Identifying the phoneme at the start or end of a word e.g., *Magic potion*

Therapist: What have you pulled out of the bag? Oh, a *star*. What sound is at the beginning of *star*? Great! Now you decide, can the *star* go into our /s/ potion?

2) Letter name / sound knowledge

- a. Learning the name of a letter e.g., *Throwing beanbags*.

Therapist: Look at this letter (shows an A4 sized page with the letter *p* printed clearly). This is the letter “p”. Now you tell me it’s name while you throw your beanbag onto the letter *p*.

- b. Learning the sound a letter makes e.g., *Posting Box*

Therapist: Now reach into my bag and pull out a letter. Which letter did you choose? And what sound does the letter “s” make? Great reading! “s” makes a /s/ sound. Let’s post your “s” into the posting box.

- c. Choosing a letter from two or more choices when given the name or sound it makes e.g., *Bouncing Tigger*

Therapist: This is Tigger, he likes to bounce. Make Tigger bounce to the letter that makes the sound “m” (Place cards with the letters m, p and s on the floor to choose from).

3) Speech target practice

- a. Introduction of target sound

Target sounds are introduced with placement cues, modelling, use of mirror etc as required.

- b. Practice of target sound e.g., *Stepping stones*

Each child has their target words placed under a row of stepping stones. The children take turns stepping to their next stone, finding a target word and practicing production.

4) *Integrated activities*

e.g., Writing on the whiteboard.

Therapist: Look at the word on the whiteboard. It says *can*. Who can see what letter is at the start of *can*? (Child A: “c”) What sound can the letter “c” make? (Child B: /k/) That’s right “c” can make a /k/ sound. We have been practicing the /k/ sound haven’t we? Let’s all make a /k/ sound for the letter “c”. (Child A, B and C: /k/) Let’s all have a turn at saying *can*. (Child A, B and C: *can*) Great /k/ sounds. Now, Jack, it’s your turn to have a go at writing. Find the letter “c” and rub it off the board. What is another letter we can put at the start to make a new word? What happens if we put an “m” at the start of *an*? That’s right, we get *man*. You write the letter “m” at the start of the word to make *man*. Now everyone have a try at saying our new word.

e.g., Driving cars

Therapist: Pull a picture out of the bag. What is your picture? Yes, it’s a *star*. Let’s all have a turn saying *star*. Don’t forget, we have to make a /s/ sound at the beginning because there’s an “s” there isn’t there. Who can show me the “s”? Let’s hear it again, *star*. Great, now can you drive your car to the letter that *star* starts with?

e.g., Mystery Bag

Therapist: Ok, now I want everyone to reach into my bag and pull out a letter. Great, what letter did you get Jack? (Child A: “p”) The letter “t”, now what sound does the letter “t” make? (Child A: /t/) That’s right. Ok, I want you to look at the pictures on the wall for a word that ends with a /t/. Can you find one? Look for a “t” on the end of the word. Great, what did you find? (Child A: *bat*) That’s great reading, *bat* does have a “t” at the end. Who’s next?

Appendix C

Treatment Fidelity Checklist

Phonological awareness intervention with integrated speech targets

Treatment session	Session includes letter name activity	Session includes letter sound activity	Session includes speech target production activity	Session includes phoneme identity activity	Session includes phoneme manipulation activity
1 3/5/06	Y	Y	Y	Y	Y
2 5/5/06	Y	Y	Y	Y	Y
3 10/5/06	Y	Y	Y	Y	Y
4 12/5/06	Y	Y	Y	Y	Y
5 17/5/06	Y	Y	Y	Y	Y
6 19/5/06	Y	Y	Y	Y	Y

Y = yes included; N = not included

Accuracy of treatment fidelity for PA intervention 100%

Morphosyntax programme alternating with articulation therapy

Treatment session	Morphosyntax or articulation therapy session	Session includes auditory bombardment activity	Session includes focussed stimulation activity	Session includes speech target introduction activity	Session includes elicited speech or morpheme production activity
1 11/5/06	Morph - third person singular	Y	Y	N	Y
2 16/5/06	Artic	Y	N	Y	Y
3 18/5/06	Artic	Y	N	Y	Y
4 23/5/06	Morph - regular past tense	Y	Y	N	Y
5 25/5/06	Morph - regular past tense	Y	Y	N	Y
6 30/5/06	Artic	Y	N	Y	Y

Y = yes included; N = not included

Accuracy of treatment fidelity for MA intervention 100%.